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SUMMARY REPORT: ENGINEERING SUPPORT TO PARR PROGRAM, 1973-1975

March 1975

Prepared for

U.S. NAVAL TORPEDO STATION
Keyport, Washington

Under Contract N00406-73-C-0631

Publication 1612-10-5-1374

ARINC RESEARCH CORPORATION

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Publication 1612-10-5-1374

ABSTRACT

Results of tasks performed by ARINC Research Corporation in support of the Performance and Reliability Reporting (PARR) system for Torpedo Mk 48 over the past two years are summarized. The Corporation provided a broad range of engineering services that contributed to the continuing development and refinement of the PARR system.

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ABBREVIATIONS

ADM	"American Dream Machine" (Lear-Seigler, Inc.)
ADP	Automatic data processing
ADPE	Automatic data processing equipment
ADS	Automatic data system
ASCII	American Standard Code for Information Interchange
ASW	Anti-submarine warfare
AUTOVON	Automatic Voice Network
BCD	Binary coded decimal
BISYNC	Bisynchronous
bpi	Bits per inch
bps	Bits per second
CDC	Control Data Corporation
CPU	Central processing unit
COMCOP	Communications cop (director)
Cps	Characters per second
CRT	Cathode ray terminals
EIA	Electronic Industry
EOT	End of transmission
ETX	End of text
GSA	General Services Administration
HCP	Hard copy printer
IMA	Intermediate maintenance activity
ips	Inches per second
JCS	Joint Chiefs of Staff
LED	Light-emitting diode
MRF	Minor repair facility
MTC	Magnetic tape cassette
NAD	Naval Ammunition Depot
NAVORD	Naval Ordnance (Systems Command)
NSSF	Naval Submarine Support Facility
NTS	Naval Torpedo Station, Wash.

NUSC	Naval Underwater Systems Center
OEM	Original equipment manufacturer
PAIU	PARR-AUTOVON Interface Unit
PARR	Performance and Reliability Reporting
QEEL	Quality Evaluation and Engineering Laboratory
RJE	Remote job entry
RRC	Repair record card
RTT	Remote transmission terminal
SUBBASE	Submarine Base
UT	User terminal
VA	Volt-amperes
WATS	Wide Area Telephone System

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1
INTRODUCTION

Since April 1972, ARINC Research Corporation has been assisting the U.S. Naval Torpedo Station, Keyport, Wash., in the implementation and continuing refinement of the Performance and Reliability Reporting (PARR) system for Torpedo Mk 48 and associated equipments. This assistance has been in the form of both specific services to meet immediate requirements or problems, and system studies having long-range implications.

During the period of the Corporation's assistance, the PARR system has expanded from a batch-reporting toward an on-line system, in which the delay time between the occurrence and reporting of events will be measured in days or hours instead of weeks. While this transition is not yet complete, significant accomplishments have been made toward that objective, some of which are described in this report.

The assistance provided by ARINC Research over the past three years has been under two contracts. Under the initial contract (N00406-70-C-0488), the Corporation developed a step-by-step implementation plan for incorporating the PARR communications capability into the NTS computer, for locating and structuring the PARR data files, and for evaluating and selecting an optimum remote terminal configuration. In addition, the Corporation generated a system plan for the continued development of PARR over the period 1973 through 1978, in which system capability will be matched in an evolutionary manner with expected demands.

Under the present contract (N00406-73-C-0631), ARINC Research has provided follow-on studies contributing to the further development of the PARR system. These studies were conducted under 15 general task headings, as follows:

Task No.	Topic	Start Date	End Date	Type Report
1	PARR System Plan	4/1/73	6/30/73	Formal
2	Data Feedback System	4/1/73	11/19/73	Letter
3	Users Manual	4/1/73	8/31/74	Letter
4	Torpedo Mk 48 Support Equipment Reporting	4/1/73	9/5/73	Letter
5	Mobile ASW Target Reporting	4/1/73	6/30/73	Letter
6	Configuration Accounting for Torpedo Mk 48 Support Equipment	4/1/73	8/6/73	Letter
7	Target Data System Reporting	8/1/73	2/28/75	Informal

Task No.	Topic	Start Date	End Date	Type Report
8	Factory Acceptance Reporting	8/1/73		Cancelled
9	Preproduction and Periodic Test Reporting	8/1/73	11/11/73	Letter
10	Communication System Studies	8/1/73	2/28/75	Formal
11	PARR Procedures Manual	8/1/73	2/28/75	Informal
12	Mk 48 Torpedo Support Equip. Deficiency Data Collection	8/1/73	9/30/74	Letter
13	ADS Development Plan	1/8/73	4/31/74	Informal
14	Dedicated ADP Requirements	4/16/74	2/1/75	Tech Note
15	NUSC Reporting Requirements	5/16/74	11/7/74	Formal

Some of these tasks comprised numerous subtasks, and a great quantity of documentation, in various forms, was delivered to NTS/Keyport reporting the results. This final report under the contract will briefly note the work accomplished under each task, and serve as a reference listing of the submittals in which the detailed results appear.

2
TASK DESCRIPTION

2.1 TASK 1: PARR SYSTEM PLAN

The PARR System Plan, ARINC Research Publication 1612-01-1-1240 (July 1973), addresses the status of the PARR system in early 1973 and the projected evolution of that system in the foreseeable future. A five-year profile of expected users and their demands is developed, and guidelines are presented for the actions and resources required to meet these demands. Also included is a summary of safeguards necessary to protect the system against intentional and unintentional degradation of integrity.

As a starting point, the System Plan assumes the implementation of a remote terminal capability for input and retrieval of information after the PARR system has been in operation for two years (early 1975). The remote terminals will provide for a basic and desirable change in PARR reporting. In June 1973 the PARR system served about 30 users requesting a monthly average of 10 reports containing some 3000 printed lines. The projected system would serve many more users requesting smaller, more specific reports – the 1978 projection is more than 100 users requesting more than 1000 reports per month, with each report being about 20 lines (to fit a remote-terminal display screen).

PARR system users in the early years (through 1975) will be predominately administrative and managerial personnel. However the balance is expected to swing toward maintenance line users in 1976 as they continue to increase in number while the quantity of administrative users remains relatively constant.

According to the System Plan the following development chronology can be anticipated:

a. Installation of a communications front-end in late 1974

b. Development of independent data and communication processors in 1975

c. Expansion of the computer complex with increasing demand until early 1976

d. Continuation of remote site development into early 1977.

Guidelines were generated for the use of communication facilities, including AUTOVON, direct distance dialing, WATS, and private lines, as dictated by usage.

2.2 TASK 2: DATA FEEDBACK SYSTEM

In Task 2, ARINC Research performed a study to demonstrate the utilization of a timely shop-reliability feedback system from the torpedo preparation sites at Cape Canaveral, NAD/Oahu, SUBBASE/New London, and Gould/Cleveland to NTS/Keyport. Results of this study were submitted to NTS/Keyport in a letter report entitled, "Study of Utilization of Shop Reliability Feedback System" (19 November 1973).

The operational concept developed in the implementation outline given in the PARR System Plan (see Section 2.1) was reviewed for adequacy, and tests were performed and operation monitored at sites where PARR equipment was installed. The data-collection concept in the PARR system is to record the data generated at operational sites onto tape cassettes, using an electronic terminal independent of a central computer. While this procedure does not entirely replace the paperwork process of filling in report forms, it does permit capture of information at the point of generation before mailing and editorial review. Daily, or more often if required, the data on the tape cassette can be transmitted over a telephone line to the central computer site for immediate processing. In this manner, data from a remote site may generally be made available within one day of a reportable event. Since the data are raw and prone to some error, transmission is followed up by normal review of the "paper" report, in context with other reports, and the computer entry corrected as required.

The error rate during data communication was measured, and the effect of this rate on data quality was estimated. It was concluded that an acceptable error rate of 1 bit in 100,000 can be achieved by regular attention to equipment testing and maintenance, and implementation of error detection measures. This error rate is approximately equal to one incorrect character in five filled-in report forms, or less than normal operator error.

In transmission tests between Honolulu and NAD/Oahu to NTS/Keyport, it was found that when transmission was acceptable for a short time period (less than a minute), it was likely to remain acceptable for about 15 minutes. This is an engineering estimate with no stated statistical accuracy.

2.3 TASK 3: USERS MANUAL

Under Task 3, ARINC Research studied the existing PARR operating procedures and the operational context in which they were developed, and then generated a users manual containing recommended procedures and documentation. As defined in the original task statement of 1 April 1973, the users manual was to be "....for use by PARR personnel, outlining data flow, review criteria, input procedures, and output selection criteria covering data received from or reported to both local and off-station sources."

As work on the manual progressed, the emphasis was changed from PARR personnel to potential administrative users of PARR data. Accordingly, the amount of descriptive information on the system was expanded (from the original intent) into a full volume; with the operator-oriented access procedures and input/output descriptions appearing in a second volume.

Work on the users manual was stopped by NTS prior to its completion, and a partially edited draft was delivered to NTS in January 1974. Editorial refinement of

the narrative, and technical updating of the appendix material, was accomplished by NTS for the production of the final user's manual.

The draft manual submitted by ARINC Research was entitled "User's Manual for Torpedo Mk 48 PARR Data System", and comprised two volumes. Volume I presented a general introduction (Section 1); a summary of the PARR program (Section 2); a detailed description of the system (Section 3); and general access procedures (Section 4). The system description included data collection, review, analysis, and processing; automation of the data system; and data input, storage, and retrieval procedures. Appendixes covered decision criteria and examples of output. Volume II summarized the PARR system products and described the access procedures in detail.

2.4 TASK 4: TORPEDO MK 48 SUPPORT EQUIPMENT REPORTING

The engineering analysis performed under this task was directed toward using the PARR system for reporting on Torpedo Mk 48 support equipment. The following was accomplished under this task:

a. Recommendations were prepared concerning implementation of support equipment reporting, and assistance was provided in developing a proposed instruction manual and format for data collection.

b. Recommendations were provided concerning data review and input procedures for supporting equipment maintenance and deficiency/logistics data reporting.

c. Support equipment deficiency reports were reviewed and categorized on a daily basis.

d. Four data summaries were submitted for incorporation into the PARR Monthly Summary Report prepared by NTS for the NAVORD Mk 48 Project Office (PMO 402).

Details appear in an ARINC Research report entitled, "Mk 48 Support Equipment Analysis and Review, Task 04 Final Report", dated September 5, 1973.

2.5 TASK 5: MOBILE ASW TARGET REPORTING

As specified in Task 5 of the contract, ARINC Research conducted a study to establish and document reporting procedures for Mobile ASW Target Mk 30 Mod 1. The reporting procedures encompassed system reliability, test equipment, documentation, and configuration reporting; with all reporting required to be compatible with the Torpedo Mk 48 PARR system.

At the request of the Target Program Manager, the study was expanded to include Target Mk 27. It was found that the Target Mk 30 procedures were, with minor modifications, fully applicable to Target Mk 27 reporting.

All elements necessary for reporting on both target systems were developed in conformity with the requirements of the study, and have been made available to NTS.

Details of the study appear in an ARINC Research letter report entitled, "Mobile ASW Target Mark 30, Mod 1 Reporting, Task 05 Final Report", August 28, 1973.

2.6 TASK 6: CONFIGURATION REPORTING FOR TORPEDO MK 48 SUPPORT EQUIPMENT

Ground rules for incorporating Torpedo Mk 48 support equipment into the PARR configuration reporting system were generated under Task 6. This task was performed concurrently with Task 4, the development of a support-equipment PARR reporting form and a proposed NAVORD instruction (see Section 2.4).

Findings of Task 6 were as follows:

a. A configuration tracking system can be implemented for Torpedo Mk 48 support equipment. This system would allow retrieval of part number (or alteration status) and serial number listings for significant support equipment items at each Torpedo Mk 48 support activity.

b. The configuration tracking system would use the proposed PARR data collection form (NAVORD 4790) to provide update information.

Results of the study are presented in the ARINC Research letter report, "Mk 48 Support Equipment Configuration Study", 27 July 1973.

2.7 TASK 7: TARGET DATA SYSTEM REPORTING

In accordance with Task 7, ARINC Research developed and documented recommended standard procedures for incorporating reliability, deficiency, and configuration data for Mobile ASW Target Mk 30 Mod 1 into the PARR system. Included was a standard procedure for the acquisition, handling, and entering into the PARR system of repair information from the manufacturer and the depots.

Following implementation of these recommended procedures, the PARR Management Information System was reviewed and audited during the Target Mk 30 Mod 1 Predeployment Test Program commencing in August 1974. Upon completion of the audit, recommendations were generated for the expansion of target system reporting to encompass mobile targets Mark 30 Mod 0 and Mark 27 Mod 0. The impact of increased target reporting was examined and a preliminary plan was recommended for implementing increased PARR-target reporting.

Documentation issued by ARINC Research under this task included the following:

a. NAVORD OD 45291, Technical Manual, Mobile ASW Target Mark 30 Mod 1 System Information Analysis System Handbook for Performance, Reliability, Maintainability, Configuration, Inventory, and Deficiency Reporting (June 1974)

b. Memorandum, Mobile ASW Target Mark 30 Mod 1 System Performance and Reliability Reporting (PARR-Target) Procedures Manual (5 June 1974)

c. Guidance instructions, Mobile Target Input Scoring Form I, "Procedures and Criteria for Preparing PARR Score Summary of Monthly Target Performance Summary Report" (July 1974)

d. Interim report, Audit of the PARR Information and Analysis System During the Mobile ASW Target Mark 30 Mod 1 Pre-deployment Program (30 September 1974)

e. Technical note, Procedures for Acquisition, Handling, and Entering into PARR System of Repair and Failure Analysis Data for Target Mk 30 Mod 1. ARINC Research publication W4-1612-TN03 (Ocrober 1974)

f. Card file, Bibliography of Reference and Source Data for the Target Mark 30 Mod 1 (November 1974)

g. Technical note, Procedures for Acquisition, Handling, and Entering into PARR System of Repair and Failure Analysis Data for Target Mk 30 Mod 1/0 at Port Allen, Kauai Pending Activation of the Remote Terminal and Hiring and Training of a Terminal Operator. ARINC Research publication W4-1612-TN03 (November 1974)

h. Attachment I to NAVORD OD 46291, Change 1, Mobile ASW Target Systems Mark 27 and 30, Maintenance, Deficiency, and Configuration Data Collection Procedures Manual (February 1975)

i. Memorandum, Audit of PARR Information and Analysis System During Mobile ASW Target Mark 30 Mod 1 Pre-deployment Program (February 1975)

2.8 TASK 8: FACTORY ACCEPTANCE REPORTING

Shortly after the initiation of this task, NTS redirected ARINC Research's efforts to other tasks under the contract. Subsequently, this task was cancelled.

2.9 TASK 9: PREPRODUCTION AND PERIODIC TEST REPORTING

ARINC Research conducted a study to determine the feasibility of incorporating Torpedo Mk 48 component preproduction and periodic production test data into the PARR system. On the basis of this study, recommendations were generated for establishing a reporting program for component test data.

This investigation entailed the development of a flow diagram depicting the sequence of events during component testing at QEEL (Quality Evaluation and Engineering Laboratory, Naval Torpedo Station); identifying at which points in the event sequence that PARR data forms are needed; a review of the current PARR form and format for the incorporation of component test data; a review of QEEL test report types to identify their significant data elements; and determining the workload required to incorporate the current backlog of component test data into the PARR system.

Details of the study, including the recommendations for implementing component data reporting, appear in an ARINC Research letter report entitled, "Study of PARR Reporting for Component Preproduction and Periodic Test Data". This report was submitted to NTS under a cover letter dated October 11, 1973.

2.10 TASK 10: COMMUNICATION SYSTEM STUDIES

Task 10 under the contract consisted of a number of subtasks, primarily of a consulting nature. The subtasks were directed toward providing quick-reaction solutions to problem areas relating to PARR communications. Therefore the reports under most of the subtasks were expediently prepared and informally submitted. Appendix A of this report presents refined and retyped versions of these informal submittals, which will be referenced as appropriate in the following brief descriptions of subtasks.

2.10.1 *Gould Network Monitoring*

Gould Ocean Systems Division, manufacturer of Torpedo Mk 48, has established a data collection and dissemination network with a central facility at Gould manufacturing headquarters (Cleveland, Ohio) and remote stations at the minor repair facilities. Under Task 10a, ARINC Research reviewed Gould plans and developed recommended techniques for interfacing the PARR and Gould networks. The objective of the monitoring and interfacing has been to provide for timely retrieval of repair record card (RRC) data and card-level configuration data.

The first general data-coordination meeting between Gould and the Navy (represented by NAVORD, NUSC, and NTS, with ARINC Research as adviser) was held in Cleveland on 30-31 May 1973. At that meeting, Gould discussed its data collection and dissemination plans, and the Navy representatives described the PARR system. The most significant conclusion from the meeting was that the interface between the two systems would be the PARR terminals at the common IMA locations. As result of this decision, the Gould terminals, manufactured by Nixdorf, were programmed by Nixdorf and Gould to emulate the PARR terminals, manufactured by Hazeltine.

Actual procurement of hardware for the Gould network was delayed until November 1973. ARINC Research maintained periodic contact with Gould throughout this period, clarifying operating concepts and technical parameters so that development could proceed with maximum compatibility with the PARR system.

In December 1973, ARINC Research requested the Chicago office of Hazeltine to loan a Hazeltine terminal to the Chicago office of Nixdorf for diagnostic testing. The terminal was made available in March 1974. At the end of March a significant milestone was reached when communication was demonstrated between the Nixdorf and Hazeltine terminals in Cleveland.

Two Nixdorf terminals were installed in May 1974 at Gould MRFs in Keyport and Oahu. In June, observations of some tests conducted by Gould indicated satisfactory exchange of information, but at a low level of throughput (between 10 and 20 characters per second). Suggestions were offered to improve the throughput to 50 characters per second or 300 words per minute, a minimum acceptable throughput considering the short message length (72 characters) and necessary line turnaround time.

2.10.2 *NAVORD Link*

A requirement exists to transfer a moderate amount of data between NTS/Keyport and NAVORD/Washington, D.C. In June 1973 an experimental link was established by using a Control Data Corporation (CDC) model 200 user terminal at Keyport to transfer data into a CDC computer in Washington, and then retrieving the data on a

DATA 100 Corporation model 78 terminal at NAVORD. This approach was not as effective as desired, and ARINC Research was directed by NTS (as Task 10b) to study alternative possibilities. ARINC Research made two analyses, one in November 1973 and an update in April 1974. The resulting reports are included in Appendix A-1.

Four alternatives are defined in the first report, given the constraints of available equipment. The Honeywell (PARR central site) computer could be modified to accommodate one of the DATA 100 terminal modes of communication. Alternatively, the DATA 100 terminal could be programmed to emulate either the Honeywell computer or the Hazeltine remote terminal, in either its PARR or non-PARR configuration. None of these approaches was judged to be entirely satisfactory, since major programming changes would be required.

In the second analysis, the Mohawk 2400 terminal was considered. It was verified that both terminals could emulate the IBM 2780 terminal, thereby communicating with each other. The IBM 2780 is a card-handling terminal using the Extended Binary Coded Decimal Information Code (EBCDIC) in a symmetrical communication line protocol. A consequence of this emulation requirement is discussed in the second report in Appendix A-1, as is the ultimate effect on information throughput. A rate of 100 characters per second is shown to be possible with the emulated IBM 2780 link over a normal telephone line. Partly as a result of this analysis, a Mohawk 2400 programmable data terminal was procured by NTS.

2.10.3 Network Testing

The problem of testing and evaluating the various portions of the PARR network was analyzed by ARINC Research under Task 10c, and a means of terminal and modem evaluation was developed for use at NTS and remote sites. A technique was also developed to test dialed connections in a general manner from the terminal through the communications to the computer. These techniques provide error detection and the possibility of recovery in a minimum of elapsed time, and are now in regular use between terminals and the central computer. Results of the study are documented in ARINC Research publication W4-1612-TN01, dated July 1974.

2.10.4 CRT Survey

Under Task 10d, ARINC Research surveyed the market for small video-display remote terminals to ensure that the most efficient and economical systems are considered for PARR system use. A survey was made of 90 models from 62 manufacturers, and the results were informally reported to NTS in July 1974.

The survey revealed that most available models are either too simple (glass teletype) or too complex (programmable intelligent units) for PARR use. Some 36 of the 90 units fell within these extremes, and generally met the technical requirements as given in Table 1 of Appendix A-2. The list was further reduced to 15 by purchase-cost constraints. Manufacturers of these 15 models were contacted by telephone to establish the availability of the equipment with magnetic tape cassette capability, hard copy printer, and through a General Services Administration contract. Justification for the initial selection of the Hazeltine terminal was determined at the time of the survey; however, reevaluation should be made periodically because of the extreme flexibility and variability of this market.

2.10.5 System Interfaces

Under Task 10e, ARINC Research was to review the physical interfaces necessary between PARR and other data systems. However, this task was postponed several times at the direction of NTS, and subsequently cancelled.

2.10.6 Smart Front-End Evaluation

Under Task 10f, a study was made of the capability and cost-effectiveness of a "smart" front-end interface with the existing PARR data processing computer. This front end would be "smart" enough to perform certain functions now handled by the computer, e.g., directing line turnaround, requesting repeats of unintelligible transmissions, etc.; and thus release more of the computer core for batch work. Results of the study, which focused on the Honeywell DATANET 2000 front-end computer, are given in Appendix A-3.

2.10.7 Terminal Equipment Testing

To support the test and evaluation activities conducted under this contract, two types of terminals were rented: a basic PARR unit consisting of a video display, tape cassette unit, and printer; and a more intelligent remote batch unit represented by the CDC model 200 user terminal.

Several of the basic PARR terminals were rented from Hazeltine; placed at NTS/Keyport and at remote operating facilities; and operated by Navy and ARINC Research personnel (Task 10g). These terminals were used to develop the required translation tables, communication techniques, operator procedures, computer programs within the central data processing computer, and equipment testing procedures.

The CDC model 200 user terminal was located at NTS. Attempts were made to interface this equipment with several Navy systems, including the PARR central data processor. The only successful interface with this terminal was with CDC computers for which it was designed. A throughput test data transfer from the PARR computer to a terminal in Washington, D.C., through the model 200 terminal showed that the path was possible, but that a great deal of time was consumed in changing media (paper to card to tape) and in procedural errors.

As a result of the successful testing activity, Hazeltine terminals were procured by NTS and integrated into the PARR data communication system.

2.10.8 Remote Terminal Requirements

Under Task 10h, ARINC Research developed a specification for the PARR remote terminal for use by Nixdorf in programming the Gould interface computer for communication with the PARR/IMA terminals. The information on which the specification was based was informally communicated via telephone to the Nixdorf office in Chicago where the software was developed. The specification itself is included as Appendix A-4 to this report.

The specification describes those characteristics of the Hazeltine terminal set utilized by the PARR data system. The equipment is capable of other functions than those specified, but those characteristics are not included since they are either 1) not actually required by the data system, or 2) made superfluous by the limited character set of the Honeywell central processor.

2.10.9 IMA Site Surveys

ARINC Research intended, under Task 10i, to survey each IMA site to coordinate procedures for telephone, terminal and modem installation, testing, and maintenance. In general, installation of the initial units went smoothly enough that site surveys were not needed. The three exceptions were at Cape Canaveral (Complex 30), at NAD/Oahu, and at NSSF San Diego.

The Cape Canaveral site was visited two times and all aspects of operation and maintenance were thoroughly investigated. Error rate tests over the 2700-mile link were very encouraging: an error rate less than 0.00001 (one bit error in 100,000 information bits) was observed.

A problem relating to procurement source delayed the installation of the terminal at NAD/Oahu. An ARINC Research representative performed the initial installation and checked out the terminal for operation. An error rate test over that link indicated considerably better service than had been anticipated, giving approximately the same performance as the link of equal length with Florida. Terminals at the outer islands of the Hawaiian group can operate with similar efficacy.

At San Diego the Survey, installation and testing were uneventful. Since the terminal was sent by the Navy from NTS to NSSF, the manufacturer does not provide maintenance in San Diego.

An alternative PARR terminal was evaluated for use in locations where the Hazeltine units are not available: the ADM-1 manufactured by Lear Siegler, Inc. It was determined that all necessary functions of the PARR terminal could be performed if a different central computer translation table were used. The table was developed and provided to NTS for incorporation into an ADM terminal handler.

Experience with variable maintenance quality and service over the wide expanse covered by the PARR network led to the recommendation by ARINC Research that a spare terminal be kept at NTS/Keyport and furnished as needed to installations having problems.

2.10.10 Computer Alternatives

An effort performed as Task 10j was that of defining and evaluating alternatives for providing the PARR communications system with a dedicated computer to act as the data communications and file management central site. The resulting report is included as Appendix A-5 herein, and is summarized below.

Sequential steps in this study were:

a. Stating the requirements of the PARR data system in terms of the functions that must be performed.

b. From these functional requirements, deriving a set of hardware and software requirements.

c. Describing the capabilities of the available equipments for meeting these requirements. This determination was based on published information, solicited industry data, and interviews.

d. Defining alternatives for the four general configuration capabilities:

   1) Communications concentration
   2) Preprocessing of data
   3) Provision of small data system
   4) Provision of complete data system

e. Determining alternative sources for procuring the various necessary parts of the system.

A conclusion favoring a phased approach was supported by both the requirements and the industry capabilities available. It appears possible to secure a data communications/file management central system that may be activated in stages, so that as each stage is completed it may be used while the corresponding capability in the existing system will serve as backup.

2.10.11 Interface Unit Requirements

Task 10k under this contract was the development of requirements for a device, for use with the PARR/AUTOVON communications network, that will satisfy the Joint Chiefs of Staff (JCS) requirement for automatic disconnection of terminals following one minute of inactivity on the line. The device will also provide some capabilities for interface testing of selected portions of the PARR communications network. The specification was informally submitted to NTS by ARINC Research, and is included as Appendix A-6 to this report.

The JCS requirement is stated in JCS Memorandum of Policy No. 151, and generally reflects current operating procedures for facsimile machines on commercial and AUTOVON lines. In those applications a mechanical unit automatically answers an incoming call and terminates ("hangs up the telephone") when the call is completed. Since those units operate at about 10% the speed of the PARR terminal, a mechanical device is considered adequate.

In the PARR network a data modem supplied by the telephone company is used that will recognize a signal at the interface to disconnect or "hang up". Most modems do not provide the disconnect function, and no commercial equipment is known that will satisfy the requirement. For this reason the requirements for a PARR-AUTOVON Interface Unit (PAIU) were defined by ARINC Research. One unit was built and tested by NTS personnel and performed fairly satisfactorily. Some difficulty was experienced in completing calls prior to automatic hang-up, and in the mechanical construction of interconnection. Since the unit is to be used in remote locations where no trained service personnel are available, and since it is in the experimental model stage at this time, it is recommended that the quality assurance provisions of the specifications be strictly observed.

2.10.12 Error-Checking Terminal Evaluation

ARINC Research evaluated, under Task 10ℓ, the feasibility of error checking at the remote terminal, and its cost-effectiveness relative to error checking at the PARR central computer.

Data quality is a prime concern in any data base operation. In the PARR system the accuracy of the decisions of Torpedo Mk 48 project personnel is affected by the

quality of the data in the master files. These data are entered by operators at remote terminals and are checked at several steps in the process for validity, both for the content of single fields and for the correlation of several fields of information. One of these steps is a process in the central computer, executed when data are input, that checks for several types of errors. On-line error correction is time consuming and makes inefficient use of the telephone lines. The study conducted under this task was intended to correct that problem by moving error detection and correction to an off-line function at the terminal.

To evaluate the requirements for error checking, the current programs were reviewed. It was noted that the following types of tests are performed:

Test	Purpose	Times Applied
Presence	Ascertains if a field contains an entry, with no regard to its value.	21
Justification	Checks to see if the entry is present, and right- or left-justified as required by the input program	4
Numeric	Determines if the entry is an alpha or a numeric value as required.	24
Length	Checks the number of characters in an entry.	12
Table Value	Checks the complete entry against a specific set of allowable entries for that field.	19

In addition to the basic single-field tests outlined above, multiple-field tests are conducted. The following single- or multiple-field tests are performed in the current system:

Fields Tested	Tests per Field	Number of Test
1	1	24
1	2	26
2	1	20
2	2	4
3	1	6
3	2	0
	Total:	80

The scope of any terminal program for checking errors should be at least as sophisticated as that outlined above, with the capability of growing to two or more times that level.

2.10.13 Data Port Efficiency Investigation

Under Task 10m, the efficiency of the present data port was evaluated and recommendations were made for increasing it. Two types of data-port operation are presently utilized in the PARR system:

a. Central office terminals connected to the computer for long periods of time while update or modification transactions are being entered; and

b. Remote location terminals connected to the computer for short periods of time for data entry and retrieval.

Various items of equipment are available which allow the connection of multiple terminals to one telephone line for access to one computer port; or more than one telephone line in call sequence order (in a manner similar to a telephone automatic call director) to one or more computer ports.

Five approaches to increasing efficiency were evaluated, and the recommendation was made that a cluster of polled terminals under a local controller be the method implemented. This approach would provide a substantial increase in efficiency at a nominal increase in cost over the present method. Details of the study are given in Appendix A-7.

2.10.14 Nixdorf-Honeywell Link

Under Task 10n, a study was performed to determine the best method of allowing the Nixdorf model 820 terminal used by Gould in the minor repair facilities to access directly the PARR central computer. The present method of access is to make a cassette recording on the Hazeltine interface terminal for relay to the PARR computer. By this method the Hazeltine terminal operates in one mode for communication with the Nixdorf terminal and in another for transfer to the Honeywell computer.

Difficulties inherent in this procedure are that 1) the communications buffers are of different lengths: 1000 characters in the Honeywell computer, 2000 in the Hazeltine terminal, and 72 in the Nixdorf terminal; and 2) the Honeywell computer does not now transmit the EOT character at the end of each transmission. Since the line length of the Hazeltine terminal is 72 characters, it can accept information one line at a time and then transmit the collection of information one-half page at a time. Also the operators of the Hazeltine terminal use the "local" button to simulate a computer EOT transmission.

There are several possibilities for resolving the first difficulty, i.e., by shortening the transmission length of the Honeywell computer. The most feasible are as follows:

a. A Nixdorf port could be developed with a 72-character buffer. Programs would then have to present data to COMCOP one line at a time instead of one page at a time.

b. Using the current 1000-character buffered ports, COMCOP or an interface program could receive data from programs one page at a time and relay them one line at a time to the port.

With the 72-character port, the first of the above alternatives, more efficient use is made of available memory space than by using only 72 of the 1000 characters in the Hazeltine buffer. On the other hand, the port would be infrequently used. When the programs have to transmit data line-by-line, their operation is not as efficient as when they deliver data page-by-page, as in the second alternative above.

Considering the above alternatives, the best approach would be to use an interface program called by COMCOP when a Nixdorf model 820 terminal is being serviced. This program would operate between COMCOP and the requested program, passing information in both directions and serving as a special-purpose Nixdorf communications "cop". On input, this "NIXCOP" would be called by COMCOP and in turn call the requested application program, passing the necessary information and setting up the working storage for output. On output, NIXCOP would accept a page of information from the application program and pass it line-by-line to COMCOP. It would use only a small amount of the available communications buffer space; however, the relatively infrequent use of this capability prior to the installation of the front-end would justify the inefficiency. Of course, the expected line speed (about 80 characters per second) will be considerably below the 120 characters per second capability of the line and the capability of the Hazeltine terminal. This situation may be compensated for by operating the Nixdorf terminal in a batch mode for short transmissions, using requests from the cassette and not from the keyboard.

The second difficulty, that of the EOT deficiency, could be resolved by implementation of any of three designs or modifications:

a. A Nixdorf port with a translation table containing the EOT character

b. A modification to the communications controller to incorporate the EOT signal in all operations

c. A modification to the Nixdorf to provide line turn-around on the ETX set as the last character of each Honeywell message.

For the reasons previously stated, a separate Nixdorf port would not be an efficient use of resources at this time. It would in this case, however, be the easiest solution to the problem.

Modifying the communications controller to send an EOT indication at the end of each message would eliminate the convenience of the current operating practice of allowing messages from the computer or other terminals to be displayed on the bottom line of the display screen. It would also eliminate multiple terminal requests. Current operation leaves both the computer and the terminal in receive at all times except when transmitting; the first one in contention for the line seizes it for the duration of its message. Only a short interval (200 milliseconds) exists when the contention cannot be resolved, and in that case the terminal retransmits.

The recommended solution is a change in the Nixdorf programming to allow line turnaround (thereby simulating the EOT) on receipt of either the ETX or EOT, instead of EOT only. Messages from the Hazeltine will be turned around on EOT, and those from the Honeywell on ETX. This might be accomplished in one program or in two separate programs, with the correct one loaded for each application.

Gould plans to use a Nixdorf unit that was moved in early 1975 from Gould's Florida office to its Cleveland office for the development of in-house configuration control applications, and could include the development of the Honeywell computer capability.

2.11 TASK 11: PARR PROCEDURES MANUAL

Under Task 11, ARINC Research reviewed PARR procedures for the Torpedo Mark 48 system. This effort resulted in the development of the PARR Procedures Manual currently used by NTS/PARR personnel.

During the performance of this task, problems affecting the deficiency data collection and logistics accounting systems were also investigated. As a result, ARINC Research proposed numerous recommendations for improvement to these systems.

The following list of submittals reflects the scope of work provided under this task.

a. Torpedo Mk 48 System Performance and Reliability Reporting (PARR) Procedures Manual (Preliminary) (30 November 1973)

b. Torpedo Mk 48 System Procedures Manual, Comments and Recommendations (30 November 1973)

c. Gould "Closure Letters", Comments and Recommendations (9 April 1974)

d. "Information Only" Reports, Comments and Recommendations (10 April 1974)

e. Utilization of "Deficiency Found During" Block on PARR Raw Data Form (30 May 1974)

f. Torpedo Mk 48 System Performance and Reliability Reporting (PARR) Procedures Manual (3 September 1974)

g. Torpedo Mk 48 System PARR Procedures, Discussion and Recommendations (3 September 1974)

h. Data Terminal Operator's Manual for Torpedo Mk 48 PARR System (Appendix G of PARR Procedures Manual) (25 Ocrober 1974)

i. PARR Products Manual (Preliminary) (24 January 1975)

j. Screen Group Procedures Manual for Torpedo Mark 48 PARR Deficiency Analysis Feedback (DAF) System (Appendix K of PARR Procedures Manual) (3 February 1975)

k. PARR Batch Reports, Analysis and Recommendations (15 March 1975)

2.12 TASK 12: TORPEDO MK 48 SUPPORT EQUIPMENT DEFICIENCY DATA COLLECTION

Problems affecting the deficiency data collection and logistics accounting systems as related to Torpedo Mk 48 support equipment were investigated under Task 12. That study resulted in numerous recommendations for improvement of the data systems, which were submitted to the appropriate PARR supervisory personnel as memorandums.

In addition to the areas covered in the memorandums, ARINC Research participated in the preparation and development of the following items as they relate to Torpedo Mk 48 support equipment:

a. NAVORD Instruction 4790.5A, Torpedo Mark 48 System Maintenance and Deficiency Data Collection Procedures Manual

b. NAVORD form 4790/7, "PARR Reliability and Maintenance Report"

c. NAVORD form 8510-48-1/66, "PARR Reliability and Maintenance Report (Feeder)"

Finally, under this task, ARINC Research conducted a study of configuration and inventory accounting for the subject support equipment. Results of that subtask are presented in company publication W4-1612-TN02.

2.13 TASK 13: ADS DEVELOPMENT PLAN

Since the PARR system makes use of automatic data processing equipment, a requirement for an Automatic Data System (ADS) plan was imposed in May 1973 in accordance with OPNAVINST 5231.1. Included in the specifications for the ADS plan were extensive requirements for communications planning and decision justification. Over a period of several months a draft version of an ADS plan was developed through a coordinated effort of NTS and ARINC Research personnel. The draft was reviewed by NTS and forwarded to NAVSEA. The plan contained the following elements:

a. Problem/Opportunity Statement

b. Environment Description

c. Objectives

d. Assumptions and Constraints

e. Alternatives

f. Costs

g. Benefits

h. Comparison of Alternatives

i. Sensitivity Testing

2.14 TASK 14: DEDICATED ADPE REQUIREMENTS

Under Task 14 of the contract, a requirements study was performed and a specification prepared for the procurement of automatic data processing equipment that would allow the PARR system to decrease its dependence on NTS/Keyport ADP hardware.

As recommended in the computer alternatives task (see Section 2.10.10), and noted in the task statement, the ADPE specification provides for the following:

a. A phased approach for progressing from a controlled front-end concentrator to a fully independent data system;

b. Satisfaction of current operational requirements with a minimum of transitional problems;

c. Growth of the data-file capability of the PARR office so that in-office storage and retrieval of an increasing amount of PARR data may be developed;

d. The expectation that several manufacturers will be able to meet the specification requirements at all stages.

The specification was prepared in military format and reflects the concept of meeting all final requirements at each of the initial stages (as opposed to the phased approach). That is, the intention is to procure all equipment at once rather than at different times. Phasing will then be reserved for capability activation rather than equipment installation. The advantages and disadvantages of this approach are discussed in ARINC Research publication W5-1612-TN01, dated February 1975.

2.15 TASK 15: NUSC REPORTING REQUIREMENTS

ARINC Research was requested, under Task 15, to define the steps needed to extend PARR reporting capabilities to include specific requirements of the Naval Underwater Systems Center (NUSC), Newport. NUSC had requested that the PARR team develop the capability to provide certain statistics on Mk 48 torpedo maintenance and logistic events. Since only some of the specific data products requested by NUSC were readily retrievable from the PARR system, it became necessary to analyze the remaining products and the PARR data-collection processes to establish a method for extracting the additional desired products. ARINC Research was requested to perform the analysis to determine means of retrieving the requested data.

It was concluded from the investigation that the desired statistics could be produced with relatively minor modifications to the existing PARR system. ARINC Research developed the specifications for the necessary PARR modifications and data processing. These represent an expansion of existing PARR capability and should improve the responsiveness of the system to future requests as well as the current NUSC request.

The recommended modifications to the PARR system, together with appropriate background information, are summarized below.

a. A composite report structure was developed through extensive coordination with representatives from NUSC and PARR. It is recommended that this structure be used for reporting the requested maintenance statistics.

b. The capability to access, via remote terminal, the source data used in developing reported maintenance statistics was also requested by NUSC. The Backup Report structure developed in this effort would provide this capability when used in conjunction with existing PARR communications programs.

c. The primary obstacle to producing these products under the current PARR system is the absence of an effective method for coding and automatically categorizing maintenance events. An extended action-coding scheme was designed during this investigation.

d. Improved flexibility and reporting accuracy would be achieved by modifying the editing and storage procedures for document control numbers, reference designators, and drawing numbers. In addition, a single site-coding scheme should be selected and used consistently to identify maintenance locations.

e. To collect and store the new data elements required, an implementation approach is recommended that includes modifying the structure and concept of F-cards in the PARR Master File to permit the storage of more detailed maintenance-event data on each component. To collect the more detailed data, modifications to the PARR report format and the in-house review process are recommended.

f. Upon implementation of the recommended PARR system modifications, the logic developed in this investigation should be used as the specifications for computer-programming activities related to the NUSC products.

The modifications recommended above, as well as an overall description of the results of Task 15, appear in the formal ARINC Research report submitted to NTS at the end of the task. That report is entitled, Systems Analysis, Mk 48 PARR Depot Reporting Procedures (publication 1612-15-4-1332, October 1974).

APPENDIX A
PARR COMMUNICATION SYSTEM STUDIES

APPENDIX A-1

NAVORD LINK EVALUATION

NTS/NAVORD DATA LINK

The DATA-100 terminal at NAVORD could be used to provide a data link with NTS/Keyport in any of several ways, all requiring some equipment modification. Both the current configurations and possible modifications will be discussed.

At NTS/Keyport the Honeywell model 2070 computer is used with a Honeywell model 286 communications controller and Honeywell model 285 communication adaptors for each of four lines. These provide 1200 bps asynchronous data links to Hazeltine remote terminals. Two other model 285 adaptors provide a 2000 bps synchronous data link to other Honeywell computers.

The DATA 100 Corp. model 78 programmed terminal at NAVORD consists of:

a. Controller - 8 kilobyte memory

b. Card Reader - 600 cards/minute

c. Line Printer - 400 lines/minute, 132 characters/line

d. CRT display - 24 lines, 80 characters/line

e. Two synchronous modem controllers - 2000, 4800 bps

Modifying the Honeywell 2070 to permit access by a conventional remote-batch terminal would benefit a wide group of Navy users who have the equipment, since the modification would not necessarily be for NTS/Keyport alone – it could be sponsored by NAVORD for all applications. The modification would be somewhat difficult in that detailed knowledge of communication disciplines and skill with Honeywell assembly language are required. Further, while the Honeywell controller software is of an efficient design, details of the design are not easily understood.

Developing a program for the DATA 100 that would emulate a Honeywell CPU would have similar benefits as the above, except that the remote terminal would have to be the DATA 100. The interface is in Honeywell code with a line control logic similar to the IBM bisynchronous communications method (BISYNC) but considerably simpler. Again, a development program would be required for some familiarity gained about Honeywell operations. Software is available for emulating the IBM 360-20, IBM 2780, Univac 1004, and CDC 200 UT in both ASCII and BCD.

Thus, there is no common set of equipment at this time. Modifications may be made to the Honeywell, the DATA 100, and/or the Hazeltine 2000. Alternatives for the data link are therefore as follows:

a. Modify a Honeywell model 2070 to emulate the counterpart of available DATA 100 terminal emulators, starting with either the Honeywell type 2440 remote transmission terminal (RTT) or central processor-to-central processor (CP-CP) controller module;

b. Modify the DATA 100 to communicate with the Honeywell CP-CP controller module;

c. Modify the DATA 100 to emulate the PARR remote terminal;

d. Modify the DATA 100 to communicate with the Hazeline remote terminal.

A disadvantage of each approach is that equipment has to be significantly modified.

Another development for the DATA 100 with direct application to PARR, but not to other Honeywell users, would be to have the DATA 100 exactly emulate the PARR remote terminal (i.e., the Hazeltine 2000 as PARR is currently using it). The advantage is that the DATA 100 user could access the Honeywell 2070 directly through available lines. It should be noted, though, this usage was not anticipated in the PARR System Plan. If the traffic becomes significant, more lines should be installed. At the DATA 100 end, an asynchronous modem controller and 202-C modem would be required.

Finally, the DATA 100 could be made to operate to the Hazeltine with the latter in some mode other than that used for PARR operation. Changes, by switch settings on the Hazeltine, might be in parity, line speed, or line discipline. This solution could be the least expensive but would require a two-stage retrieval of data.

ARINC RESEARCH CORPORATION
INTEROFFICE MEMORANDUM

TO: H. Trueblood
Keyport Section

DATE: April 23, 1974

SUBJECT: Work Order 1612-10,
Subtask B

REPLY TO: SNA/ENG-74-33
W.O. 1612-10

REFERENCE: SNA/74-04, dated 9 Jan 74

FROM: J. Fountain
Santa Ana

A review of the capability of the NAVORD DATA-100 terminal to communicate with the planned NTS MOHAWK 2400 terminal was requested under this work order task. The referenced memo contains the previous site descriptions and recommendations. The documentation on both indicates that they can emulate the IBM 2780 Data Transmission Terminal. This terminal is designed to communicate with a variety of IBM equipment including another 2780. Therefore, it can be planned to use this mode of operation from NTS to NAVORD.

It is important to select the correct emulator because most remote batch terminals such as the CDC 200 UT and the IBM 360/20 can communicate with computers having the appropriate responsive line logic. They cannot, in general, talk to each other since the line logic is not symmetrical. The computer will poll and the terminal will respond to that poll.

Selecting the emulator imposes the restrictions inherent in the terminal emulated. The IBM 2780 is designed as a card handling terminal. All data is therefore blocked in 80-character blocks with a maximum of 400 characters in any one transmission. Since the 2780 operates half-duplex; at the end of each transmission the line is turned around for a block acknowledgement. Space compression is available if the transmission code is EBCDIC thereby increasing the throughput. This is not available in USASCII code operation. A tape prepared on the Honeywell must therefore be prepared as EBCDIC card images to be transmitted most efficiently.

In order to estimate the actual throughput, an effective line speed must be calculated taking into account the propagation time for each message over the 3000 miles between Keyport and Washington, the expected error rate over the line to be used, and the size of the transmitted block which must be retransmitted if an error occurs. Considering a dial-up WATS line, the modem rate would 2000 bits per second. At an error rate of 1 bit in 10,000, the effective line speed with the optimum block size of 200 characters is 1432 bits per second with full duplex operation. Bringing in propagation and acknowledgement protocol, the effective line speed drops to 800 bits or 100 characters per second.

The implication of the above calculation is best seen as determining the time required to send a tape from NTS to NAVORD. If the tape contained 400-500 pages, the approximate number of characters would be 3 million. At the theoretical maximum effective line speed of 2000 bits-per-second (250 characters-per-second) the tape would go in just over 2 hours. However, at the realistic rate of 800 bits-per-second (100 characters-per-second) the tape would take over 8 hours to transmit. The communications costs could become significant if the number of tapes to be exchanged were large.

In summary, the NTS and NAVORD terminal can communicate with each other exchanging information as if they were IBM 2780s. The only problem associated with this operation is the time it will take to transmit a large amount of information from one place to the other. Possible improvements include a dedicated, data-conditioned 4-wire line or more sophisticated modems and software for higher speeds.

J. Fountain

JF:gr
cc: R. Taylor

APPENDIX A-2

SURVEY OF CRT DISPLAY MODELS

To determine the most cost-effective CRT display unit for PARR remote terminal applications, ARINC Research surveyed 90 CRT units of 62 manufacturers. Table 1 lists the criteria for an acceptable CRT display model. Most models surveyed were either too simple (glass teletype) or too complex (programmable intelligent units) for PARR use. Of the 90 units surveyed, 35 were selected as meeting most technical requirements. Table 2 identifies the candidates and notes any desirable features that might be lacking.

The 35 candidates meeting the technical requirements were reduced to 16 by application of the applicable price constraint (requirement 13, Table 1). Manufacturers of this group were contacted by telephone to determine the availability of magnetic tape cassette (MTC), hard copy printer (HCP), and General Services Administration contract. The survey has been updated several times in the past year; latest results are given in Table 3.

The selection requirements given in Table 1 were developed around current experience with existing terminals, and are commented on below. The numbers preceding the comments correspond to those in the first column of Table 1.

Item of Table 1	Comment
1	A nominal 2000-character display has been found essential for most PARR data forms. A great deal of information may be on a PARR form; having the entire form available for display in a structure similar to that on paper promotes faster operator training.
2	While there is no need for lower-case character display, the terminal should display upper case letters (26), numerals (10), and a reasonable number of special characters (28), yielding a total of 64 display characters.
3	A method must be available to indicate fixed and variable data in a form fill-in application without blinking, i.e., variable intensity.
4	The current system operates at 1200 bps with even parity, asynchronously with keyboard control of "Request To Send".
5	Remote positioning of the display cursor will allow special report formatting for low-error visual interpretation.
6	Efficient use of communication lines require continuous block or message formatted data. The current block size is 1000 characters.
7	Off-line editing is required to provide easy correction of invalid data, compensating for the loss of keypunch verification on data input.

Table 1 Item	Comment
8	Fixed-form data should be protected from accidental erasure by the operator.
9	To minimize block size, only variable data should be transmitted.
10	Full control and operation of tape and printer peripherals must be available off-line for data capture without using communications or computer time.
11	Peripherals must be included in the supplied and maintained terminal set. The storage medium must have two accessible locations, e.g., a dual cassette tape, for multiple forms and data.
12	Since NTS is the purchaser, a valid GSA contract must be in force, with a desirable feature being that all equipment be available on lease.
13	For purposes of establishing a dividing line between "more" and "less" intelligent terminals, an arbitrary purchase price limit of $4000 is set for CRT.
14	Adequate equipment is available for a lease period at less than $350 per month.

TABLE 1. CRT DISPLAY REQUIREMENTS

1. 2000 character display (minimum = 72 x 24 = 1728)
2. 96 ASCII character set, 64 displayed
3. Variable intensity, background/foreground
4. 1200 bps asynchronous controllable parity
5. Cursor positioning
6. Page or block mode with 1000 character minimum
7. Editing of character and line
8. Protected (unerasable) form-data
9. Transmit data only for short messages
10. Off-line data input, editing, and peripheral control
11. Dual-drive tape and printer peripherals
12. GSA contract available
13. CRT purchase less than $4000
14. Total GSA lease for less than $350 per month

TABLE 2. CANDIDATE PARR TERMINALS (Sheet 1 of 2)

Manufacturer	Model	Lacking Features	Cost ($)	Candidate
Ann Arbor Terminals, Inc.	KSR 200	Char/line insert	1,021	X
Applied Digital Data Systems	Consul 980	None	2,800	X
Automatic Electronics, Inc.	85 Series	None	4,000	X
Beehive Medical Electronics, Inc.	Super Bee	Off-line operations	2,600	X
Burroughs Corp.	TD 800	Off-line editing, variable intensity	4,750	
Computek Inc.	200	Block transfer	4,000	
Computer Communications	CC-30/40	Variable intensity	6,000	
Conrac Corp.	401	None	2,200	X
Control Data Corp.	713-10	Limited editing, 300 bps max.	1,995	
Courier Terminal Systems	Executerm	Page mode	3,400	
Datamedia Corp.	Elite 2500	Off-line operations	2,000	X
Delta Data Systems, Inc.	5000	None	3,000	X
Hazeltine Corp.	2000	None	2,995	X
IBM Corp.	3270	Off-line operations	4,000	
Infoton Inc	Vistar GT	Editing	1,600	
International Comm. Corp.	40+	Off-line operations	3,850	X
ITT Data Equipment and Systems Div.	3100	Variable intensity, off-line operations	6,150	
Jacquard Systems	100	Page mode	3,400	X
Lear Siegler	ADM-1	Off-line operations	2,595	X
Megadata Computer & Communications	S:R-1000	Off-line operations, page mode	2,950	
Olivetti Corp. of America	TCV-270	Off-line operations	4,000	
Omron R&D Inc.	8025	None	2,350	
RCA	II	Custom program	6,000	

TABLE 2. CANDIDATE PARR TERMINALS (Sheet 2 of 2)

Manufacturer	Model	Lacking Features	Cost ($)	Candidate
Research Inc.	Teleray 3300/II	Editing, split screen	1,200	
Sanders Data Systems Inc.	804/810	None	6,055	
Sycor Inc.	250	Split screen	4,310	
SYS Computer Corp.	820	None	6,000	
TEC Inc.	400	Split screen, variable intensity, Xmit data	2,860	
Tektronix Inc.	4023	None	2,995	X
Teletype Corp.	40	Cursor control	3,625	X
Texas Scientific	Entelekon 100	None	4,200	
Trivex Inc.	Plus 70	Split screen, I/D line, page mode	5,652	
Westinghouse Canada	1620	None	2,180	X
Wiltek Inc.	500	Split screen	5,000	
Wyle Computer Products Inc.	8000	I/D line, field protect, off-line operations	4,850	

TABLE 3. FINAL SELECTION OF PARR TERMINAL

Company	MTC	HCP	GSA	Notes
Hazeltine	Yes	Yes	Yes	
Ann Arbor Terminals	No	No	No	
Applied Digital Data Systems	No	Yes	Yes	Cassette interface and floppy disc interface
Automatic Electronics	No	No	No	OEM supplier
Beehive Medical	No	No	No	
Conrac	No	No	No	OEM supplier
Datamedia	No	No	Yes	Printer buffer
Delta Data	Yes	Yes	Yes	No GSA lease
ICC-Milgo	No	No	No	Printer interface
Jacquard	No	No	No	Disc and printer interfaces
Lear Siegler	No	No	Yes	GSA purchase only, printer interface
Omron R&D	No	No	No	GSA bid in, cassette and printer interfaces
Tektronix	Yes	Yes	Yes	Both floppy disc and cassette
Teletype	No	Yes	Yes	
Westinghouse	Yes	Yes	No	GSA purchase only, 2% discount

APPENDIX A-3

EVALUATION OF SMART FRONT-END

As Phase 2 of PARR system development,* a "smart" interface between the existing data processing computer and the communication lines for the PARR system is being considered. This appendix reviews the capability and cost-effectiveness of that technique for releasing data processing computer core for batch work; and evaluates, from the terminal user's viewpoint, system operation with the new front-end.

1. CURRENT OPERATIONS

Communications control is now a function of the data processing computer. Program software includes a communications policeman and communications controller. Computer hardware includes core storage, multichannel communications control (1 per 64 lines), communications line adaptors (1 per line), and movable-head disk storage.

Data are input from a remote terminal over dialed telephone lines to the line adaptor, then to the multichannel control for buffer storage. The communications controller manages the transfer to temporary disk storage and then on to the communications policeman for transfer to a requesting program. Output data follow the reverse path: program, policeman, controller, disk, data buffer, multichannel control, line adaptor, telephone line, and remote terminal. The disk storage allows multiple input/output messages during program delays. The approximate amount of storage now used is:

a. Policeman – 5,000 words of core

b. Controller – 20,000 words of core

c. Multichannel control – 2,000 words of core

d. Disk – 20 cylinders, 500,000 characters

2. FRONT-END OPERATIONS

Under the "smart" interface concept, all control of communications is moved to a dedicated communications processor (e.g., the DATANET 2000) for front-end operations. This frees the data processing computer from that task, although it must still handle communications between requesting programs and the front-end. Front-end software would include a data processor, consisting of a communications policeman (one in each partition) and a communications interface module; and a communications processor or controller. The hardware includes:

a. Data Processor

– Interface module hardware

– System buffer core storage

*See PARR System Plan, *ARINC Research Publication* 1612-01-1-1240, p. 3-1

b. Communications Processor

- Processor CPU
- Basic multiline controller (2 for 24 lines)
- Line interface modules (1 for each line)
- Fixed-head disk storage
- Control console

Data are input from a remote terminal over dialed telephone lines to the line interface module, then to the multiline controller for placement in buffer core storage. The communications controller software manages to transfer to temporary disk storage, and then to the coupler buffer when requested by the data processor. The data are then routed through a high-speed channel from coupler buffer to system buffer in the data processor, and on to a policeman for transfer to a requesting program. Output data follow the reverse path from program to remote terminal. As in the present system the disk is used to compensate for program delays, but here it is also used for communications processor recovery from failure. Recovery records and tables are maintained on the disk. The approximate amount of storage which might be used in the front-end is:

a. Policeman – 2,000 words of data processor core

b. Interface module – 4,000 words of data processor core each

c. Communications controller – 40,000 words of communications-processor core

d. Disk – 500,000 characters

3. COMPARISON OF ALTERNATIVES

It can be seen from the above operating summaries that the functioning of the two front-end alternatives is quite similar. The manufacturer (DATANET) has gone to great effort to accomplish this similarity to make the transition to a "smart" front-end a smooth one. Assuming two partitions, one for communication and the other processing batch work, the core storage requirements in the data processor is reduced from 25,000 to 8,000 words of core. The 17,000 word reduction is accomplished by adding 40,000 words of communications processor core. This is quite efficient, considering the overhead functions required.

Possibly more important than the core savings is the reduction in the number of interrupts to data processor operations. When the data processor handles communication control, those interrupts occur frequently – as often as once per character. With front-end operation, the character interrupts are in the communications processor. Only one interrupt is required in the data processor for each message or message segment (from 1 to 4,000 characters).

The performance impact of a reduction in interrupt frequency is difficult to assess because the reduction is only effective during actual data transfer. With a large communications traffic load, however, the impact would be significant. This impact could be evaluated by benchmark testing with and without communications functioning.

"Transparency" is a major attribute of both alternatives. In each, the terminal user is aware only of sending messages to and receiving messages from an active program. The advantage of this transparency is the apparent simplicity of the data transfer process. The disadvantage is that no isolation is provided between the user and data processor problems.

In the PARR System Plan discussion of Phase 2 operation with a front-end, it was pointed out that the front-end should provide several features, including error checking and address processing. These features would enable the communications processor to perform some tasks without bothering the data processor (like a good secretary). They also allow the network to continue functioning at a reduced level of effectiveness when the data processor is down. It is conceivable that the DATANET 2000 could be programmed to accomplish this backup operation; however, no such provision has been made.

Operational flexibility is significantly greater with the front-end alternative, since terminals with special characteristics may be specified and translation tables may be modified under standard provisions rather than requiring custom programming as is now the case.

APPENDIX A-4

SPECIFICATION FOR PARR REMOTE TERMINAL SET

1.0 SCOPE

This specification describes the functional and electrical characteristics of the PARR Remote Terminal Set. The set provides complete data acquisition, formatting, storage, retrieval, display, and communication facilities; and may be used in certain NAVORD data collection and reporting programs where independent terminal operations are necessary.

2.0 APPLICABLE DOCUMENTS

a. EIA Standard RS-232C, Interface Between Data Processing Equipment and Data Communication Equipment, August 1969

b. ARINC Research Corporation, PARR System Plan, publication 1612-01-1-1240, July 1974

3.0 REQUIREMENTS

3.1 GENERAL

The PARR Remote Terminal Set shall be a stand-alone, alphanumeric CRT unit with magnetic tape cassette, printer, and modem. This set shall have the overall capability of displaying 1900 alphanumeric characters to store, retrieve, and print data; to provide local and command editing; and to transmit and receive digital information at speeds up to 1200 bps.

3.2 DISPLAY UNIT

3.2.1 Display Characteristics

Display-unit characteristics of the Remote Terminal Set shall be as follows:

a.	Minimum character capacity:	24 lines of characters, 74 characters per line; screen capacity: 1900 characters
b.	CRT display:	12-inch diagonal CRT; standard raster: 525 lines, 30 frames/sec.; optional raster: 625 lines, 25 frames/sec.
c.	Character style:	5 x 7 dot matrix pattern
d.	Character repertoire:	64 USACII alphanumeric characters plus one special symbol
e.	Character size:	*Nominal character height: 0.119 inch* (6-inch raster height)

f. Split screen: Two video intensities shall be available (full intensity in foreground, low intensity in background) and controllable by the remote CPU.

3.2.2 Communication Interface

a. Data transmission rate: Standard (1200 bps)

b. Data interface: Shall be EIA RS232-C with Bell 202C type data set compatibility. A front-panel toggle switch shall permit channel turnaround on EOT code in normal PARR operational mode.

3.2.3 Functional Description

3.2.3.1 Operating Modes

The display unit shall be capable of operating in one of three modes: batch, half duplex, and full duplex. The normal PARR mode is batch, in which data are entered from the keyboard or from the tape cassette unit onto the display screen. Editing controls allow the following functions from keyboard and CPU:

a. Insert line
b. Delete line
c. Insert character*
d. Delete character*
e. Clear screen
f. Clear foreground
g. Cursor controls*
h. Home cursor
i. Address cursor**
j. Print
k. Transmit
l. Set foreground
m. Set background

3.2.3.2 Data Transmission

Data shall be transmittable to one of the following units:

a. Modem for communication
b. Tape cassette unit for storage
c. Printer for hard copy.

*Not available for CPU
**Available only for CPU

3.2.4 Keyboard

The keyboard shall contain three keyboard groups: teletype, a 10-key adding machine, and 13-key editing and cursor control. The keyboard enclosure shall contain the following elements:

a. Indicators

(1) Transmit

(2) Print

b. Pushbuttons

(1) Power on/off

(2) Break

(3) System reset

c. Indicator/pushbutton combinations

(1) Receive mode indicator/set to receive and local mode

(2) Local mode indicator/set to local mode only

(3) Parity error indicator/reset parity error indicator

The keyboard shall contain no mechanical contacts and shall be removable. An additional power on/off switch shall be on the front panel of the display for power turnon when keyboard is removed.

3.2.5 Display Installation

Display installation requirements shall be as follows.

3.2.5.1 Power Requirements

a. Primary Power — Line cord shall be 7 feet long, 3 wire, fixed to terminal; 300 volt-amperes maximum; 115/230 Vac, 50/60 Hz, nominal input. Power settings:

(1) Low: 90/180-110/220 Vac

(2) Med: 104/208-126/250 Vac

(3) High: 114/224-136/272 Vac

b. Circuit Protection — Dc power supply shall shut down automatically for overvoltage, short circuit, or overtemperature condition. Power supply shall be resettable by turning primary power off for 5 seconds.

3.2.5.2 Environmental Requirements

a. Temperature: 10° to 40° C

b. Humidity: 90% relative humidity, noncondensing

3.2.5.3 Physical Characteristics (Nominal)

a. Dimensions (with keyboard):

(1) Height: 12.5 inches (31.8 cm)

(2) Depth: 22.0 inches (55.9 cm)

(3) Width: 18.5 inches (47.0 cm)

b. Depth with keyboard removed: 16 inches (40.6 cm)

c. Dimensions (keyboard only):

(1) Height: 2.8 inches (7.1 cm)

(2) Depth: 6.1 inches (15.6 cm)

(3) Width: 18.5 inches (47.0 cm)

d. Weight with keyboard: 62 pounds (28.2 kg)

e. Electrical cable/connector interfaces

(1) Keyboard to display — 5-foot (1.52 meter) cable from keyboard, terminated with 54-pin HDR-series connector. Mating connector on display rear panel.

(2) Display to data set — 10-foot (3.05 meter) cable from display terminated with DB25-P connector.

3.3 MAGNETIC TAPE CASSETTE

3.3.1 General

The magnetic tape cassette unit shall consist of two independent tape transports capable of record and playback digital data. The transport shall mechanically accept standard (Phillips) tape cassettes. Operation shall be initiated through either remote CPU command or operator action. The operator shall be able to control tape operation through the keyboard controls located on the cassette console. The console shall consist of 13 lighted pushbuttons, four indicator lights, and two tape-engaging levers.

3.3.2 Functional Description

The tape cassette shall perform three functions:

a. Keyboard entry

b. I/O receive/record

c. Data playback/transmit

Each of these functions shall have two modes of operation: continuous and block.

3.3.2.1 Data Playback/Transmit-Block Page-Off Line

The operator shall initiate playback via a tape cassette console. A single block of data shall be played back to the display. Playback shall be terminated at the end of each block.

3.3.2.2 Keyboard Entry-Block Mode-Off Line

Tape recording shall be initiated by depressing a command ("SHIFT PRINT") at the keyboard. The transfer rate of data from the terminal to the tape cassette shall be 2400 baud, with the keyboard inhibited during transfer. (This mode allows a block to include up to 1,997 characters.)

3.3.2.3 Data Playback/Transmit-Block Page-On Line

The playback mode shall be initiated via the tape cassette console upon receipt of an "X ON" command. A block of data shall be played back and displayed, and when playback is complete the block shall automatically transmit to the CPU. A "RESET" command shall clear playback.

3.3.2.4 I/O Receive/Record-Block Mode-On Line

Data shall be loaded into the terminal buffer and tape cassette buffer simultaneously at the baud rate selected by the terminal.

3.3.2.5 Keyboard Entry-Continuous Mode-Off Line

A carriage return (CR) typed on the keyboard shall initiate "RECORD TAPE", and transfer the data from the terminal to the tape cassette. Transfer shall be at 2400 baud, and during the transfer keyboard functions shall be inhibited. (In this mode of operation the display will roll up under keyboard entry.)

3.3.2.6 Data Playback/Transmit-Continuous Page-On Line

The operator shall initiate playback via the tape cassette console. The tape cassette shall play back a block of data to be displayed, and the block shall be automatically transmitted to the CPU. At the end of data transmission the tape cassette shall play back the next block and the cycle will be repeated. Playback shall be terminated at the end of the file. The display shall clear at the beginning of each block.

3.3.3 Software Control

When the tape cassette system is on line, the CPU shall be able to transmit codes to simulate the following operator actions:

Action	Control Shifted Period Followed by:
a. Playback 1	@
b. Playback 2	P
c. Record 1	Ø

Action	Control Shifted Period Followed by:
d. Record 2	Ø
e. Rewind 1	←
f. Rewind 2	0
g. Reset	SPACE

A delayed X-ON option shall be incorporated into the tape cassette to make the following sequence possible at 1200 bps:

a. Reset, rewind, playback

b. X-ON EOT

The second command shall cause 1) control to shift to the terminal, and 2) the transfer of one record from the cassette to the screen, with subsequent transmittal. Control shall then be returned to the computer.

(NOTE: As a consequence of the above option, the capability of the terminal to respond to the remote transmit command is eliminated.)

3.3.4 Tape Cassette Console Controls

Tape cassette console controls shall be as follows:

a.	Playback 1:	Initiates playback of cassette #1 except in block on-line mode, where it conditions cassette for response to "X ON".
b.	Playback 2:	Controls cassette #2 as described above.
c.	Record 1:	Enables recordings to be made on cassette #1.
d.	Record 2:	Enables recordings to be made on cassette #2.
e.	Rewind 1:	Causes cassette #1 to rewind to clear leader.
f.	Rewind 2:	Causes cassette #2 to rewind to clear leader.
g.	Reset:	Clears all modes of operation and generates an inner-file gap if in the record mode.
h.	Interlock:	Must be depressed simultaneously with record to prevent accidental recordings.
i.	Block/continuous:	Determines mode of operation.
j.	On line:	Enables CPU operation and automatic transmit.
k.	Duplicate:	Enables duplicating from one cassette to the other. Duplication shall terminate at the end of each block if the system is in the block mode, and at the end of a file if the system is in the continuous mode.

l. Page/character: "Page" will route the data to the Hazeltine 2000 for display. "Character" will transmit directly to the CPU at the baud rate selected by the Hazeltine 2000.

m. Power on

3.3.4.1 Electrical

Input/output data rate:	2400 baud, or any baud rate selected by the display. All inputs and outputs shall be TTL (transistor-transistor logic) compatible.
Recording format:	Phase encoded single track — read/write head, 0.056-inch track width.
Recording density:	400 bpi/800 bpi
Forward speed:	6 ips ± 2% long-term stability; servo controlled
Start/stop time:	40 milliseconds each
Rewind time:	90 seconds, maximum; head retracted (typically 50 seconds)
Inter-record gap:	100 milliseconds
Inter-file gap:	1 second
EOT/BOT:	Optical sense clear leader; indicator on console displays status
File protect:	Switch closure senses absence of file, protects tab located at the rear of the cassette. Indicator on console displays status.

3.3.4.2 Physical

a. Height: 6 inches (15.2 cm)

b. Depth: 16 inches (40.5 cm)

c. Temperature: 10° to 40° C

d. Width: 15-1/2 inches

e. Weight: 31 lb (14 kg)

f. Humidity: Up to 90% relative without condensation

g. Interface: 3 foot (91.4 cm) cable terminated with a 54-pin header connector. Mating connector shall be on the CRT terminal.

3.3.4.3 Power Requirements (Nominal)

Nominal power requirements of the tape cassette console shall be as follows:

a. Line cord shall be 7 feet (2.13 meters) long, 3-wire, fixed to terminal.

b. Load: 100 VA (standby), 130 VA (one cassette forward), 250 VA (both cassettes rewinding); 115/230 Vac, 50/60 Hz nominal input. Power settings:

   (1) Low: 90 to 110 Vac, 180 to 220 Vac

   (2) Med: 104 to 126 Vac, 208 to 250 Vac

   (3) High: 114 to 136 Vac, 224 to 272 Vac

3.4 HARD COPY PRINTER

3.4.1 General

The printer unit shall be provided as an accessory to the PARR terminal, and shall provide the user with a choice of hard-copy printing options as discussed below.

3.4.2 Functional Description

3.4.2.1 On-Line Mode

The printer unit shall provide hard copy, on an 8-1/2 inch paper roll, of all data exchanged between the computer CPU and the terminal. Printer operation shall be at the same speed as the terminal-computer system, i.e., 10, 15, or 30 characters per second. This mode shall not normally be used, since the speed of PARR operations is 120 characters per second.

3.4.2.2 Off-Line Mode

The operator shall be able to print off-line directly from the terminal core memory. The print function shall be controllable through software, or simply by the operator depressing the PRINT key at the terminal console. The PRINT key shall interlock with the SHIFT key, with both depressed to initiate a print operation. The off-line printing rate shall be 30 characters per second regardless of the baud rate of the terminal-computer network. In the off-line mode, the operator shall be able to select directly from the terminal screen what he wants printed.

3.4.3 Software Control

The printer shall respond to the following CPU commands:

Command	Control Shifted Period Followed by:
a. On-line	1
b. Off-line	?
c. Print	ASCII "SO"

APPENDIX A-5

PARR COMPUTER MECHANIZATION ALTERNATIVES

1. INTRODUCTION

The Performance And Reliability Reporting (PARR) system was established to provide timely, high quality data on the performance, reliability, and other operational aspects of the Torpedo Mk 48 Weapon System and associated equipment. Inherent to the objective is a requirement to collect, store, and retrieve a large amount of data.

Mechanization of the PARR data system computer has proceeded from card-oriented and batch-operated to disk storage-oriented and real-time operated. During this transition the computer has remained essentially a single-program machine, with the real-time operation concept forcing communications and application programs to compete for resources. Program loading and unloading take up a significant portion of computer time, and terminal operation is slow when many terminals are using the system.

This study had the purpose of examining the alternatives available at this time and in the foreseeable future to increase the efficiency of mechanization of the PARR data system. The approach taken has been to examine current operational practices and available commercial hardware and software to identify both short-term and long-term alternatives. Some alternatives that are probably unacceptable have been included in order to define clearly the limits and rationale of acceptability. Decisions are outlined which, when made, will provide the policy base for development of a procurement specification for a PARR dedicated computer.

2. SUMMARY AND CONCLUSIONS

A wide selection of computer hardware and accessories is available that allow the input, storage, and retrieval of data in real time. These items are sold by manufacturers as part of either original equipment manufacturer (OEM) or "turn-key" systems. Software for these computers are available from both hardware and software-only suppliers, and from organizations that have developed in-house applications.

Few manufacturers have developed software for supporting data equipment, preferring to supply lower-level (with respect to COBOL) assembly languages, such as BASIC and FORTRAN, in which the purchaser can prepare his own control programs. The critical deficiency in most of the machines, as far as PARR is concerned, is the unavailability of COBOL on small computers. While the small-batch models from large computer manufacturers offer this language, COBOL compilers are available on only three types of minicomputer. The degree of compliance with the Navy COBOL requirement in this instance should be reviewed.

An evolutionary approach to development of an independent capability appears possible, but is not immediately obvious. That is, there is no available equipment that can be configured in a minimal form as a preprocessor or input data processor, and in a larger form as a complete data management system. A stepwise approach from a communications-oriented to a data-oriented machine is possible, as is the use of a data-oriented machine initially for communications purposes.

3. REQUIREMENTS

PARR mechanization requirements are discussed below in terms of functional, hardware, and software categories. Functional requirements are derived from functions performed by the present system; and hardware and software requirements are then derived from the functional needs. The equipment capabilities needed to meet these requirements will also be discussed.

3.1 FUNCTIONAL REQUIREMENTS

The primary functional requirements of the PARR data system is to support a variety of data input and retrieval demands simultaneously, providing up-to-date, useful information in display or printed form, both periodically and on request. This requirement identifies the uniqueness of the PARR system relative to the typical airline reservation or business system, or commercial time-sharing computer network. In the PARR system, many remote terminals perform essentially the same function and require support by only one program, which may be written in machine language and optimized for efficiency. In the latter systems, the terminals all control their own programs, performing different functions; and require support by compilers and a flexible operating system, one that can accommodate many simultaneous programs.

In the PARR data system, input and file maintenance use from 5 to 10 programs, each tailored for a specific application. More than 20 retrieval programs may be available in the near future, each also formatted to provide support for a specific application. All programs require maintenance periodically, so must be written in a high-level language. Further, most terminals will be used for both data input and retrieval, thereby requiring access to both sets of programs.

The following functions are required for the PARR data system:

a. Real-time system supervision

b. Permanent storage of data on magnetic tape

c. Temporary storage of a significant portion of the data file on magnetic disk

d. Tape file maintenance

e. Disk file maintenance

f. Disk/tape file loading and unloading

g. Data management control capability

h. COBOL programming language support

i. Assembly language programming support

j. Multiple simultaneous application support

k. Report printing

l. Local terminal support

m. Remote terminal support

n. Data input to mass storage

o. Data retrieval from mass storage

Combinations of these functions will be made in order to implement the following configuration capabilities:

a. Communications concentration

b. Data preprocessing

c. Small data system with current data only

d. Complete data system

3.2 HARDWARE REQUIREMENTS

The major hardware elements needed to fulfill the functional requirements of the PARR data system are the central processing unit (CPU), storage facility, communication facility, and printing facility.

3.2.1 Central Processing Unit

The CPU provides real-time supervision over that portion of the data system operations being managed at the site where the CPU is located. Significant features of a CPU performing real-time functions are:

a. Real-time operating system

b. Real-time clock available to software

c. Memory protection

d. Instruction relocation

e. Hardware interrupts

f. Input/output channels

g. Priority interrupt structure

h. Paging or virtual memory

i. Direct memory addressing

j. Fast register status storage

These features allow the CPU to maintain control of operations and respond to the demands made upon it by peripheral equipment.

3.2.2 Storage Facility

Temporary and permanent storage hardware accessible by the CPU in the form of core, disk, and tape are necessary to provide data storage functions. This may be short-term storage while the data is enroute to the central computer, or it may be the complete file.

Significant features affecting real-time operation are core size and speed relative to the intended application. Limited core will require loading of only portions of an executing program, with other portions on disk-stored pages saved for loading when needed. Therefore a minimum of 64,000 bytes of core or equivalent fast-access storage is required.

Program page swapping can consume a significant amount of time. Small and slow-access disk storage will slow down the paging process and impede access to stored data. Therefore a fixed-head disk of 2 million-byte capacity is required.

Considerable physical movement of disk arms may be required in random-access disk storage. However the entire data file must be stored with room for 5 year's growth, and thus moving-head disk storage of 150 million characters is required (100 million characters currently and growing at the rate of 10 million characters per year).

3.2.3 Communication Facility

The communication facility must include hardware for handling local terminals, remote terminals, and intersite communications. A minimum of 15 ports is required (see PARR System Plan, Section 5.2).

Local terminals are those directly connected to the computer, with no use of commercial or private telephone lines. At least 500 feet of separation from the central computer should be allowable in the local terminals.

Remote terminals are those located anywhere in the world having access to the computer through telephone lines. The current PARR data system operating speeds are 10 and 120 characters per second.

Intersite communication is over short distance (about 2,000 feet) and long distance (thousands of miles). Over the short distance, from the PARR office to the data processing center, either multiple terminal or single preprocessor channels are needed. The long distance intersite link, for example from Keyport to Washington, D.C. or Hawaii, would require at least one high-speed dedicated channel.

3.2.4 Printing Facility

Because of the large volume of printed reports generated by the PARR system, a high-speed printing facility is required (at least 600 lines per minute).

3.3 SOFTWARE REQUIREMENTS

PARR functions that depend upon software for realization are real-time system supervision, data management control, COBOL program language support, and assembly language support. The most critical of these functions is COBOL support, since most small computers already provide high-level language support in BASIC, FORTRAN, ALGOL, or RPG. In any event, some high-level language is required for program preparation.

Assembly language programming capability is needed for programming the specific interfacing terminals of remote processors, including the Honeywell computer. In most cases, it should be easier to modify the remote processors.

4. CAPABILITIES

The previous section addressed PARR data system requirements independently of whether they could be realized in a practical configuration. In this section, the capabilities of available hardware and software are summarized in the areas where PARR requirements have been stated.

4.1 HARDWARE CAPABILITIES

Central processing units within the scope of the PARR requirements are generally classified as minicomputers. However a distinction between the two is being drawn with increasing word size, memory capacity, and processing sophistication of computers. A minicomputer has historically been characterized by small physical size, processing capability, configuration availability, software support, word length, cycle rate, and cost. The direction of evolution has been toward a continuing reduction of these features. In the early 1970's, word lengths decreased from 16 to eight bits, cycle rates from two to one microsecond, and costs from $20,000 to $15,000. In the last two years, some manufacturers have increased word size to 32 bits, retained a less-than-one-microsecond cycle time, increased overall sophistication, and raised the cost to $30,000 or more. A wide variety of peripherals is now available, including 50,000,000-character disk drives and 600 line-per-minute printers.

Table 1 summarizes operational characteristics of a cross-section of small computers. This information was obtained from published surveys and manufacturer interviews.

Storage devices are available in a variety of forms. Magnetic core is generally offered in 4,000 or 8,000 character increments to a total of 128,000 characters. Disk storage is either fixed-head, with a 10-microsecond access time; or moving-head, with a 50- to 100-microsecond access time. Fixed-head disks hold less than 500,000 characters, while moving-head disk packs hold up to 200 million characters per drive. The advantage of the larger disk size is the lower cost per bit of storage. For example, increasing drive size from 2.5 million to 50 million bits could reduce the cost per bit stored from $5 to 50¢. Of course, the drive utilization is also an important factor. The large size of the PARR files and the scope of requests from those files would seem to dictate a relatively large, well organized moving-head disk. Considerations of reliability could dictate two smaller units.

TABLE 1. CHARACTERISTICS OF SELECTED MINICOMPUTERS

Manufacturer	Hardware Characteristics		Peripherals		Software Language	
	Memory, K-bytes	Cycle Time, usec	No. of Instruct.	Disk Pack M-bytes/Drive	FORTRAN	COBOL
Data General	132	0.8	100	12.5	X	X
Digital Equipment Corporation	124	0.9	413	40.0	X	X
General Automation	128	0.8	82	12.5	X	
Hewlett Packard	128	0.8	170	47.0	X	X
Honeywell	64	0.78	100	15.0	X	
Interdata	1028	0.75	240	12.5	X	
Modcomp	250	0.8	145	25.0	X	
Prime	256	0.6	100	12.5	X	
Raytheon	64	0.8	130	52.0	X	X
Texas Instruments	64	0.75	120	100.0	X	
Varian	256	1.0	100	25.0	X	

(1) All have real-time operations, data character (byte) moving instructions, real-time clock, and range of peripherals.

(2) Data current as of July 1974.

Communications capabilities are generally characterized by speed and flexibility. PARR terminals are presently connected to the central site by a switched telephone network at 120 characters per second (cps). This allows a low error rate and flexibility of interconnection, with message times of less than 10 seconds. More terminals can be accommodated by adding more off-line capability so that actual telephone call time is shortened. Five computer lines could then, for example, accommodate ten terminals.

Putting more than one terminal on a line would mean changing the computer communications controller (e.g., to the Hazeltine 3000) to provide for addressing of terminals. Another alternative is to use a cluster of terminals under one master control, such as the Honeywell MTS 7500, and changing the Honeywell controller to handle this configuration. As another example, a terminal trunking feature is an option of the Mohawk 2400; data terminals can be located up to 2000 feet on shielded cable from the Mohawk location.

Communications speed in the Honeywell is limited to 2400 bps (300 cps) per line unless the DATANET 2000 is used as the communications processor. In that case the upper limit is 10,800 bps. A concentrator in the PARR office would communicate with the Honeywell over several dedicated 2400-bps lines with Bell type 201 modems The number of lines needed would depend upon the total traffic load. In all probability, considering the inherent delays in the Honeywell processing, only one line would be required for eight to ten terminals. This line would accommodate 35 to 45 messages per hour.

5. MECHANIZATION ALTERNATIVES

The alternatives for mechanizing the PARR data system to increase its efficiency will now be discussed in terms of the configuration capabilities outlined in Section 3. Table 2 shows these capabilities and the relative size or type of hardware and software available to implement the configuration.

TABLE 2. PARR CONFIGURATION CAPABILITY ALTERNATIVES

Configuration Capability	Processor	Storage	Printer/Copier	Software
Concentrate Communications	Small	Small	None	Assembly
Preprocess Data	Medium	Medium	None	Package
Provide Small Data System	Medium	Large	Yes	COBOL
Provide Complete Data System	Large	Very large	Yes	COBOL

Communications concentration is a relatively small task requiring a small processor, small storage, assembly language software, and no peripherals. This would allow several terminals to access the computer over the same telephone line.

Preprocessing of data requires a slightly larger processor to make decisions about fields and their validity. A moderate amount of storage would be needed if the data were to be collected on a tape or disk. The data preprocessor software could be a data management package, allowing specification of the validity requirements for each field.

A small data system would include some or all the hardware and software necessary to implement the system, but only enough storage to provide for a small amount of data (say six months). A complete data system would include enough computer power and addressable storage to accommodate the current system and provide for expected growth over the next two years.

6. ACQUISITION ALTERNATIVES

Table 3 shows, in matrix form, the nine alternatives for procuring data-processing systems. Acquisition sources are 1) a manufacturer, 2) an original equipment manufacturer (OEM) who assembles components, and 3) a turn-key supplier who provides a working total system. Items they can provide are divided into the collective categories of components, all hardware, hardware and software, and hardware with a data management package.

TABLE 3. ALTERNATIVES OF DATA SYSTEM ACQUISITION

Item	Source		
	Manufacturer	OEM	Turn-Key
Components	1	X	X
Hardware	2	3	X
Hardware & Software	4	5	6
Hardware & Data Mgmt. Package	7	8	9

Procuring components from a variety of manufacturers (alternative 1) is probably the most common approach in developing data systems of this type. Standardization is such that small manufacturers can specialize on one peripheral type and sell it both openly on the market and to original equipment manufacturers. While this approach would be economical for a single-location commercial business, it is not appealing to a widespread network such as PARR. If it were considered for use only at NTS, assurances from the manufacturer would be necessary concerning maintenance support at the station. In this alternative, the software would have to be developed by the station from an assembly-language or FORTRAN compiler.

Procuring all hardware from a single manufacturer (alternative 2) is unlikely since most suppliers are OEMs for only a portion of a system. For example, Honeywell's MTS 7500 is a Honeywell DATAPOINT 2200/3300 combination with custom software to accomplish the multifunction terminal operation. An OEM, on the other hand, generally manufactures one or several segments of a system and packages the other segments under his name (alternative 3). In so doing, the manufacturer assumes the responsibility for the support of the total system. For example the Hazeltine printer is made by Texas Instruments and supported by Hazeltine. These alternatives again would require the complete development of software by NTS, probably in assembly language.

There are further alternatives to procuring combinations of hardware and software. Again a single manufacturer (alternative 4), unless it were IBM, could not supply both portions. The OEM goes beyond supplying the hardware and adds software of the types he is probably most competent to prepare (alternative 5). Only the largest OEMs supply the complete line of hardware and software, including high-speed line printers and COBOL. Turn-key system suppliers (alternative 6) have software tailored to specific operations such as general ledger or commercial BASIC timesharing. If PARR applications were such that they would not change with time, then a turn-key system might be appropriate. These applications will change, however, and PARR will continue to write programs to cope with the changes. From this point of view, then, a turn-key procurement is probably not advisable.

Hardware and data management package could be obtained from all three sources. An example of this alternative would be the Mohawk 2400. With one set of options this system supports remote terminals in a key-disk or key-tape mode. The system is composed of a minicomputer, storage, terminals and a data management package of software. Whether procured from a manufacturer (alternative 7), OEM (8), or turn-key source (9), the package approach leaves limited flexibility. In some cases, as with Cincom System's "*Total*", *MRI Corporation*'s "*System 2000*", and other general data base management systems, flexibility is great. The flexibility of the offering is therefore the question of interest, and these alternatives should be kept open for consideration.

APPENDIX A-6

SPECIFICATION FOR PARR INTERFACE UNIT

1.0 SCOPE

This specification describes the functional, physical, and electrical characteristics of an interface unit to be used with remote terminals of the Performance and Reliability Reporting (PARR) network when operating on the Automatic Voice Network (AUTOVON). The purpose of this device is to provide automatic disconnection of the terminal in the event of inactivity for a specified period of time. Secondarily, the device will indicate the presence of electrical signals at the interface.

2.0 APPLICABLE DOCUMENTS

The following documents form a part of this specification to the extent that they are referenced herein:

a. JCS Memorandum of Policy No. 151, "Autovon Operation Criteria"

b. EIA Standard RS-232C, Interface Between Data Terminal Equipment and Data Communication Equipment Employing Serial Binary Data Interchange

3.0 REQUIREMENTS

3.1 EQUIPMENT DESCRIPTION

The PARR-AUTOVON Interface Unit (PAIU) is a portable device that can be connected physically and electrically to the interface between the PARR terminal and a telephone company modem. The PAIU satisfies the requirements (para 41) of JCS Memo 151 (reference a) for automatically limiting the use of the terminal on AUTOVON circuits. In addition, it monitors the presence of interface signals and provides a test plug for signal injection and evaluation.

3.1.1 Interface Definition

Figure 1 is a simplified drawing of the elements of a PARR remote terminal connected to the central computer site. Telephone-line equipment may be either commercial or AUTOVON-dialed networks. Interface characteristics of the terminal and modem are defined by EIA Standard RS-232C (reference b).

3.1.2 Hardware Definition

The hardware shown in the PARR system diagram of Figure 1 consists of:

a. The PARR terminal, including keyboard, display, printer, and cassette units

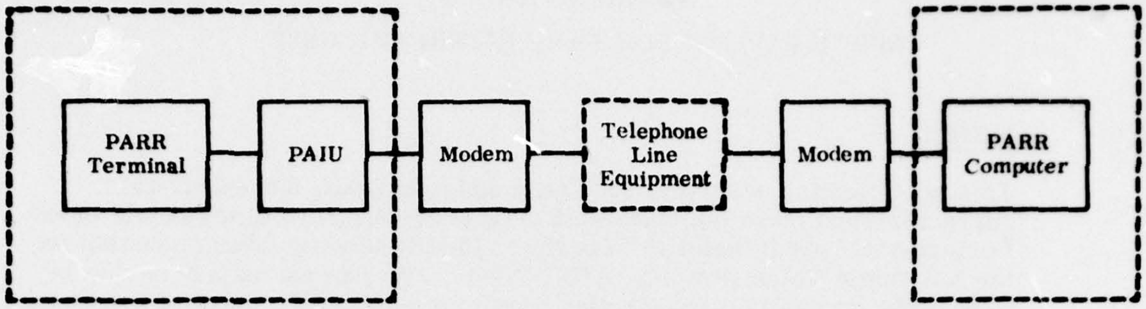


Figure 1. Simplified Interface Diagram

b. The PAIU, defined by this specification

c. A modem (Bell type 202C) operating at 1200 bits per second.

All connectors are 25-pin, RS-232C compatible plugs (Cinch or Cannon Co. type DB25P or equivalent) or sockets (Cinch or Cannon Co. type DP25S or equivalent) as appropriate.

3.2 CHARACTERISTICS

3.2.1 Functional

The PAIU performs two principal functions: signal monitoring and automatic disconnect. A general functional block diagram is shown in Figure 2.

3.2.1.1 Signal Monitoring

At the line speed being used in the PARR network, 1200 bps, only a half-duplex signal can generally be transmitted or received at one time over a dial-up line. Under this condition, data transmission, line control, and equipment status signals can be profitably monitored to indicate source of trouble in cases of communication problems. The following circuits of the interface shall be monitored for signals between +3 and +25 volts with LED or equivalent indicator lamps:

Circuit	Pin	Name
BA	2	Send Data
BB	3	Receive Data
CA	4	Request to Send
CB	5	Clear to Send
CC	6	Data Set Ready
CF	8	Carrier Detect
CD	20	Data Terminal Ready

Impedance to the data circuit shall be greater than 30,000 ohms.

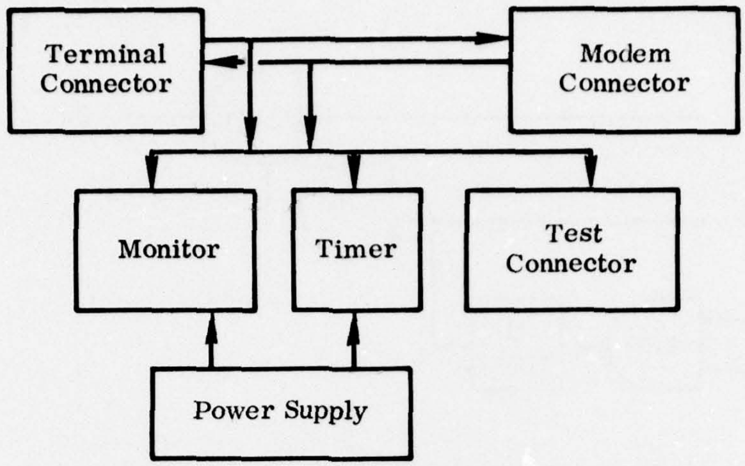


Figure 2. General Functional Block Diagram of PAIU

In addition to lamp monitoring, a test connector shall be provided to allow access to data circuits BA and BB. It shall be possible to transmit to or receive from the terminal or modem.

3.2.1.2 Timed Disconnect

For AUTOVON lines, JCS Memo 151 (para. 4i) requires the automatic disconnect of a data terminal to "free the circuit after the device is inactive for a period of one minute". This function shall be accomplished in the PAIU by a timer that will be started when a connection is established, and then reset by data transfer in either the send or receive directions. At the completion of the timed interval, circuit CD, "Data Terminal Ready", shall be turned off. When the call is disconnected as indicated by circuit CC being turned off, CD shall be returned to "on" for the next call. An override switch shall be provided for use of the terminal on non-AUTOVON circuits. Figure 3 illustrates the required PAIU switching logic.

3.2.2 Physical

3.2.2.1 Transportability

The PAIU shall be packaged in one case and designed to be portable.

3.2.2.2 Durability

The PAIU shall be packaged to withstand normal handling in on-site operation such as may be encountered when it is operated with the PARR terminal. The PAIU shall withstand a drop from a height of three feet without impairment of functional characteristics.

3.2.2.3 Safety

The PAIU shall use no internal secondary power greater than 40 volts. The primary ac power circuit shall be fuse-protected and frame-grounded with a third conductor.

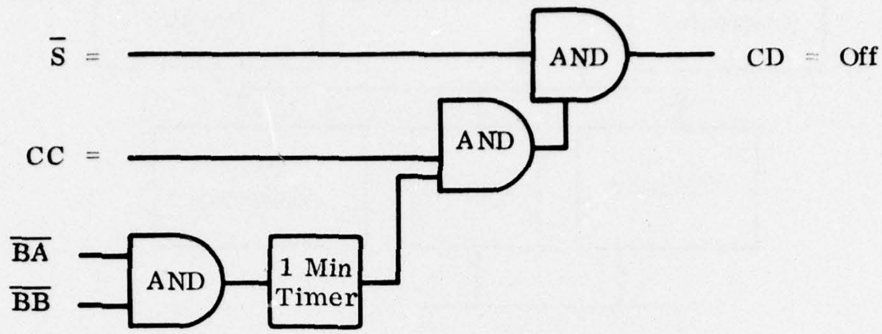


Figure 3. PAIU Logic Diagram

3.2.3 Human Factors

The PAIU shall be designed to be used at a remote location by clerical personnel. Controls and markings shall be conveniently located and clearly marked.

4.0 QUALITY ASSURANCE PROVISIONS

4.1 TESTING

4.1.1 Call Initiation

The PAIU shall be inserted in the specified interface, and then several calls will be initiated to the central computer on another terminal. The following shall be verified:

a. With no data transfer, the circuit is disconnected in approximately one minute.

b. With intermittent data transfer, the circuit is not disconnected.

c. After some data transfer, when data is stopped, the circuit is disconnected after approximately one minute.

d. The override switch will disable the timer in steps (a) and (c) above.

e. After hang-up, another call can be initiated with no need to switch off terminal or modem.

4.1.2 Call Answering

The PAIU shall be inserted in the specified interface and several calls made to it from another terminal site. The following shall be verified:

a. The modem will auto-answer and operation can proceed as tested in Section 4.1.1.

b. Several messages without EOT, simulating tape, or printer control, can be sent to the terminal, thereby resetting the timer on each message.

c. Disconnecting the controlling terminal telephone circuit will cause the remote terminal to hang up in approximately one minute.

5.0 PREPARATION FOR DELIVERY

The PAIU shall be packed in a manner that will provide adequate protection during normal freight transfer.

6.0 NOTES

6.1 DEFINITIONS

The definitions of RS-232C (reference b) apply to undefined terms of this specification.

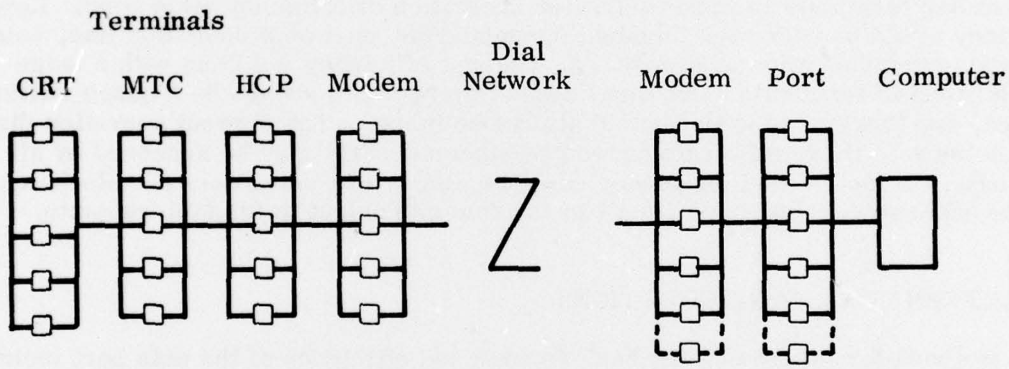
APPENDIX A-7

DATA PORT EFFICIENCY STUDY

Under task 10m, a study was conducted of PARR data port efficiency and recommendations were made for increasing it. Five alternative equipment configurations have been identified that would enhance data-port efficiency by the connection of either 1) multiple terminals to one telephone line for access to one computer port, or 2) more than one telephone line in call sequence order to one or more computer ports. This report gives an analysis of present telephone traffic and discusses the alternatives for handling it more efficiently.

1. ANALYSIS OF TELEPHONE TRAFFIC

The reliability block diagram for the present PARR office terminals is shown below.



As indicated in the diagram, a great deal of redundancy is available, providing for graceful degradation of performance as individual equipments fail and are slowly repaired.

A group of five terminals, operating twenty 8-hour days per month at an effective production rate of one character per second at each terminal, produces:

$$\left(5 \text{ terminals}\right)\left(\frac{1 \text{ char.}}{\text{sec/term.}}\right)\left(3600\ \frac{\text{sec}}{\text{hr}}\right)\left(8\ \frac{\text{hr}}{\text{day}}\right)\left(\frac{20 \text{ days}}{\text{mo.}}\right)\left(\frac{1 \text{ card image}}{80 \text{ characters}}\right)$$

or 36,000 card images per month. This theoretical value is in good agreement with the 40,000 to 50,000 card images actually produced under conditions and operating procedures at the time of this study (1974). The true capability, however, may be two to three times the present rate (one character per second) because of the advanced editing characteristics of the terminal and real operator keying ability. That is, the five terminals could probably process collectively some 100,000 to 150,000 card images per month.

With reference to the dial network communications lines, one line can handle a throughput of

$$\left(1 \text{ line}\right)\left(\frac{120 \text{ char.}}{\text{second}}\right)\left(3600 \times 8 \times 20 \ \frac{\text{seconds}}{\text{month}}\right)\left(\frac{1 \text{ card image}}{80 \text{ char.}}\right)$$

or 430,000 card images per month per line, considering a 50% utilization of the line.

It is evident, therefore, that the current system concept emphasizes simplicity, low cost, reliability, and availability at the expense of performance (throughput), thereby operating at a low level of efficiency. An increase in efficiency is possible by several routes, each involving an increase in system cost (dollar and effort) and a decrease in reliability/availability. In all cases, efficiency is increased by sharing ports among terminals to achieve greater utilization of communication time. Lowest efficiency would be with each terminal occupying one port on a dedicated line, using it only when communication is necessary. Highest efficiency would be with a large enough group of terminals using one line that there would always be a queue waiting for service, and therefore the line would always be in use. The current operation dial-up lines is between these efficiency extremes since all ports may be accessed by all terminals. In fact, a high efficiency could be attained by using only remote-batch or remote-job-entry techniques with all input from and output to the tape cassette.

2. ALTERNATIVE CONFIGURATIONS

Methods for increasing the performance and efficiency of the data port include the following:

a. Adding more terminals of a similar type to increase performance and require remote job entry (RJE) operations;

b. Enhancing current port capability on the central computer with a port expander to provide rapid switching between waiting calls;

c. Adding a cluster controller to the present terminals to control terminal access to the computer;

d. Changing to computer-polled terminals;

e. Changing to a cluster of polled terminals with polling cluster controller.

Each of these alternatives will be briefly discussed and evaluated.

First, the current concept could be continued with the addition of more terminals of the same or similar type. As has been noted, any desired increase in efficiency could be obtained by performing more operations off-line in an RJE environment. (It might be pointed out that the Honeywell computer would operate more efficiently in this mode since it was designed for this type of operation.) The only operational procedure now requiring a continuous on-line terminal is that of modification. This requirement could be changed by initiating a procedure that would allow a list of PARR forms needing modification to be requested and put on tape cassette. Modification would be performed off-line from one cassette to the other, and the modified data input from the second cassette. Each time a terminal operator wanted to use a line, the operator would dial the connection and stay on-line only until the tape operations were finished. While this procedure would produce a high communications efficiency, it would place a greater load on the terminal operator.

More ports with a flexibility in speed and interconnection could be achieved with the use of a port expander or selector at the central computer. This device, an interface between the dedicated or switched modems and the computer ports, functions as both a rotary switch and port interconnector. Manufacturers of such devices include Infotron Systems Corp. and Data Products/Telecommunications Division. Infotron's Timeline 450, in its basic configuration, can be used to interface 16 lines with eight ports; and has an ultimate capability of interfacing 254 lines with 124 ports. The port expander scans the modem lines (ring indicator) until an access request is found; and then scans the ports until it finds one of the proper type available. The port and line are connected and activity monitored until the call is over, upon which it disconnects the line and makes the port available for another call. In addition, most port expanders continually provide status indication and diagnostics. A device of this type is highly recommended for consideration as the next step in PARR communication enhancement beyond the front-end planned for installation early in 1975.

The last three approaches (c, d, and e, above) involve the use of some form of polling. In all cases, the poller is a node or bottleneck in the network through which all traffic must pass and on which all operation is dependent. The reliability of the polling device is therefore important.

Adding a cluster controller to the present terminals consists of placing a contention resolution device or distributor between one modem and a group or cluster of terminals. When one terminal wants to use the line, it requests it. If the line is free, the distributor connects the terminal to the line modem for transmission of one message, at which time the distributor disconnects the terminal and resumes scanning for access requests. While one terminal is connected, the others are denied the clear-to-send signal so that they will not interfere. The main advantage of this device over other, more sophisticated types is its simplicity and reliability. Operator control is uncomplicated, involving no new switches or lights. One disadvantage is that during a long search time, while the terminal is waiting for a reply from the computer, no other terminals may use the line. Another disadvantage is that cassette operations would not be possible.

A change of terminals to one intelligent enough to be polled by the computer or the front-end would transfer the control of communications from the terminal to the computer. This intelligence implies some preconceived notion of the manner in which the terminal is to be used since it is the procedure that is programmed into the terminal. Some of the most common notions are that a human operator is always present, since a display screen is being used; only one page is sent in one message, since the operator must decide what to do with a page or it will be destroyed by overwriting;

and control of peripherals such as the tape cassettes and printer are at the operator's option, and not available to the computer. In a manner similar to that of the above-described cluster-controlled terminal, an operator prepares a message on the screen and requests to be polled. At the next polling cycle the computer accepts the message and prepares the terminal to receive a response. When the response is ready, the computer sends it to the terminal. While one terminal is sending or receiving, all others are inhibited; however, between the input and output messages at one terminal, the computer may exchange messages with other terminals. There is provision for character and message parity checking, automatic retransmission of bad messages, and automatic recovery from undefined situations.

Advantages of pollable terminals are realized when there are enough terminals to maintain a high level of traffic flow at all times. Then the communications efficiency may be kept high. Disadvantages include the special computer programming needed to support polling, and the dependence on computer reliability for continued operations.

The two concepts of cluster and polled operation can be combined, with the controller doing the polling and controlling the terminals in the cluster. At a low level of intelligence the controller can only maintain communications, but with additional capability can perform error checking as well. In most configurations, for example the Honeywell MTS 7500, tape cassettes and disk storage are available to continue operations when the central computer fails. After messages are received and stored by the controller, it builds a queue of the messages and transmits them to the central computer. When responses are received, they are routed in the same manner back to the requesting terminal. The only central computer programming necessary is the tracking of messages by terminal address. A standard 2000 bit-per-second interface can be used between the controller and the central computer. Interface characteristics would be the same for both the Honeywell 286 and the DATANET 2000 communications processors.

3. COST/EFFICIENCY CONSIDERATIONS

Efficiency and cost are the major factors to be considered in selecting the most desirable alternative for increasing PARR data port efficiency.

Reliability is a major factor affecting efficiency. Independent operation may be sustained when the central computer fails; but without a backup controller, operation is now dependent upon the controller. Adequate provision for spare parts and service must be assured when this approach is used.

Costs can range from less than $36,000 for a contention controller to more than $50,000 for a terminal cluster with polling. The current level of cost for five terminals is $35,000 (based on a value of $7,000 per terminal set including display, tape cassette, and printer).

For the first alternative, adding terminals, costs increase in increments of $7,000 to $42,000, then $49,000, etc. The second alternative, adding a port expander, would cost approximately $5,000, making a total of $40,000. The third alternative, cluster terminals, would range in cost from $13,000 to $36,000 depending on the number of cassettes and printers used with the cluster. The lower figure is for display terminals only. The fourth alternative, polling terminals, would range in cost from $15,000 to $37,000, also depending on the peripheral equipment. The

fifth alternative, polling cluster terminals, would have a base cost of approximately $40,000 for a five-terminal system with a completely redundant controller adding $13,000 to the price. The redundant controller could be used for a variety of small computational tasks during its standby status.

In summary, the lowest cost and lowest performance alternative is the cluster terminal set costing about $13,000. This configuration would increase communication efficiency at the cost of system reliability and local recording/printing capability. The highest cost and highest performance alternative is the polling cluster terminal set costing about $40,000. The latter alternative offers a significant increase in system efficiency at a nominal increase in cost, and is recommended.